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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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The International Foundry Congress at Düsseldorf

It is something of an achievement for the foundry industry to have assembled together in one town more than 2,200 of its members coming from twenty different countries. The British delegation, headed by Mr. H. Winterton (President of the Institute of British Foundrymen), numbered well over a hundred. The reception given to the delegates was both hearty and sincere. The great circular hall of the Planetarium was almost overfilled for the opening ceremony. A splendid orchestra played operatic overtures, and lent a certain theatrical atmosphere to the proceedings. This illusion was heightened rather than dispelled when the various speakers climbed to the rostrum to deliver their addresses. Dr. Schacht, the Finance Minister, spoke of peace and industry, while the Lord Mayor wore not the traditional scarlet and ermine robe but the khaki uniform of the governing party. The opening luncheon, though somewhat marred by a rather late start, proved to be an excellent function. Between the reception and the luncheon there was just time to take a glance at the Exhibition. Hurried though it was, it was sufficient to impress one by the wideness of its scope and the thoroughness of its organisation. Of the nine halls about four were devoted to purely technical matters, which covered every phase of foundry practice. The moulding machine firms unquestionably supported the exhibition loyally, and never in England has there been such a choice of machines, ranging from the simple hand-strip variety to an almost completely mechanised plant for making baths by jar-ramming—a plant which, it is rumoured, is destined for shipment to England.

Time permitted us, unfortunately, only to participate in two of the works visits. The first was the Rhenania sheet enamelling works at Schwelm, which was opened to members of The Institute of Vitreous Enamellers. The stamping and spinning departments were particularly well equipped and some of the enamel colours produced were excellent, especially the blues. Our second visit was to Humbolt-Deutz at Cologne, and here extremely high-grade castings are made under eminently satisfactory conditions. An electric furnace is used for superheating the iron, and in the heavy section a partial mechanisation has been carried out by feeding sand on a belt conveyor running under the crane track to sand-slingers. All the cupolas have specially-designed teapot-spouted receivers, except a small cupola which serves a large well-laid-out area reserved for training apprentices.

The technical sessions have been well attended by the German participants, but because of language difficulties not by the English. A few English delegates, however, were present to support Mr. J. G. Pearce when he presented the Exchange Paper on behalf of the Institute of British Foundrymen. Mr. Colbeck and Mr. Evans joined in the discussion of Dr. Paschke's Paper on a phase of blast-furnace practice.

The weather fortunately was quite brilliant and the delegates were unanimous in their very sincere appreciation of the many courtesies showered upon them by their hosts. The International Technical Committee has recognised this by electing Mr. Bannenberg, of Velbert, as the Vice-President, which implies that when the International Conference comes to London in 1939 he will be the principal guest. Düsseldorf has indeed made a serious contribution to international foundry co-operation and to the recognition of the importance of the industry by a much wider public than heretofore. For this and for the all too generous hospitality we can best say—Tausendmal Dank und Glückauf.

Casting-Consciousness—III

We concluded in our second leader on this subject that there was room for some form of development organisation for the founding industry, in which all castings, at any rate those made from ferrous materials, could have their applications and markets expanded, and we suggested that such a body might cover all ferrous cast materials. The obstacles to such a body are several. Many makers of castings for their own use do not regard themselves as founders, with the result that if an alternative competitive material were found preferable they would make that instead. This is, of course, a sound reason for an organisation. The main handicap, however, lies in the long-recognised difficulty of persuading founders to act together to any common end. The enormous strength of the steel industry owes not a little to the existence of the British Federation of Iron and Steel Manufacturers. The founding industry does not come into the Federation as such, and we have reluctantly to admit that the trade associations of founders are not sufficiently representative, and the difficulty of making them so is always being lamented by their officers. We recognise the difficulty that a maker of pallet plates has in seeing anything in common with a maker of machine tool castings,

(*Concluded on page* 228.)

The International Foundry Congress at Düsseldorf

The British party which left London by the Harwich-Hook route last Monday week to participate in the International Congress, were, on arrival at Düsseldorf, joined by members of the British Cast Iron Research Association. The latter had previously made an extensive tour of the foundries in Switzerland and South Germany. The two parties, together with a few arrivals by air and motor-car, numbered over a hundred. The opening afternoon was rather spoilt by a heavy thunderstorm, but by the evening the weather had cleared up, and it remained fine for the rest of the conference.

The works which had been visited by the B.C.I.R.A. party included those of Sulzer Brothers at Winterthur (Switzerland) and Ludwigshafen (Germany); Heinrich Lanz A.-G., Mannheim; Humboldt Gasmotorenfabrik Deutz, Köln; Honselwerke A.-G., Meschede, Ruhr; Fried. Krupp A.-G., Essen; Eisengiesserei Rödinghausen, Menden; Warsteiner Eisenwerke A.-G., Warstein; G. Zimmermann A.-G., Düsseldorf, and Schiess-Defries A.-G., Düsseldorf.

The next morning there was the opening of the "Bureau," with its usual scramble for tickets, but, as is customary, Mr. Makemson came to the rescue. It does present a problem when members of twenty nations, numbering well over 2,000 persons, arrive at a counter all at approximately the same time. The tickets were contained in a flap of a folded programme, staggered in such a way that each day stood out clearly and facilitated rapid reference.

In the afternoon, most of the British party went by an excursion steamer down the Rhine to Duisburg, where there was the opportunity to inspect two of the local foundries. Others visited one of Krupp's foundries at Essen. In the evening there was a reunion in an ancient hostelry attached to a brewery.

The Opening Ceremony

It would be difficult to find a more appropriate setting for the opening of an International Congress than the Planetarium at Düsseldorf. The building is virtually circular, and the serrated brickwork beneath the galleries gives an illusion of a densely packed arena. All the front seats were reserved for the foreign delegates. On the stage was the municipal orchestra, conducted by Mr. Hugo Valzer, and as soon as the company were assembled there was an excellent rendering of the "Klänge der Euryanthe" overture.

Sitting at a table just below the stage were Mr. W. Bannenberg, the President of the Central Committee for the Foundry Industry, who presided; Mr. J. Léonard, the President of the International Foundrymen's Technical Committee; Baron von Wittgenstein, President of the German Foundry Employers' Federation; Dr. M. Langenhohl, Director of the Economic Section of the Foundry Industry; the Ober Bürgermeister of Düsseldorf, Dr. Wagenführ; Dr. Geilenkirchen, Editor of the "Die Giesserei"; and a few representatives of the scholastic profession.

The CHAIRMAN, on mounting the rostrum, after referring to the pioneer work of Mr. Ropsy in the stabilisation of international foundry co-operation, announced that the following telegram had been sent to Herr Hitler:—

> "On the occasion of the opening of the Foundry Congress and of the Sixth Foundry Exhibition being held in Düsseldorf from September 17 to 27, 1936, and on behalf of the twenty nations gathered together, I send to you, Leader and State Chancellor Adolf Hitler, our respectful greetings.—Signed Léonard."

He thanked all the various State, educational and municipal authorities for the help they had given towards making the conference a success, especially Dr. Wagenführ, the Lord Mayor of Düsseldorf. He pointed out that the exhibition was primarily designed to show the existing state of the science of foundry practice and to indicate likely channels of future progress. It was expected that about 20,000 people would see the exhibition before it closed. He regarded this congress as a real factor in the cultivation of true international friendship. He offered a very sincere welcome to all the delegates.

MR. LÉONARD, as President of the International Committee, replied on behalf of the whole of the guests. He emphasised the debt of gratitude they owed to Mr. Bannenberg and his colleagues who had given up so much time for the benefit of their guests.

MR. LANGENHOHL then took the rostrum to thank Dr. Schacht for personally coming from Berlin to be with them. He hoped that the work they were doing would enable German foundrymen to produce castings of still higher quality at a lower price.

Dr. Schacht's Speech

From the back of the room, DR. SCHACHT came forward amidst loud applause, and having referred to the restricted space and opportunities for livelihood open to the German people he said that Germany would follow the work of the congress with the greatest interest, because she saw in it one of the factors which helped to improve the lot of the masses by peaceful means. He knew himself to be at one not only with the leaders, but all circles of the German nation, when he laid emphasis on the word *peaceful*. The German people had not given up hope of a peaceful solution of the problems of life of the various nations or of the will to achieve it. The history of our own time showed that war, whether it ended in victory or defeat, offered no contribution to the prosperity or peace of the nations. Peace and order, the life and prosperity of the nations, were in the long run to be won only through a peaceful understanding of technical possibilities. He then declared the conference to be opened and wished it every success.

The final speaker was the LORD MAYOR OF DÜSSELDORF, who accorded to the delegates a civic welcome, and expressed the hope that he would meet them all again at the Zoological Gardens, on the occasion of the Rheinische evening, which the city was offering for their enjoyment.

At this point a telegram was received from Herr Hitler reciprocating the greetings sent, and containing good wishes for the success of the congress.

Opening Luncheon

It took some considerable time to seat all the delegates in the magnificent Hall of the Rheinterrasse Restaurant. The speeches of Dr. Schacht and Mr. J. Léonard were commendably short and to the point. The menu, which included a dish of the famous Rhine salmon, was excellent.

Committee Meetings

Later in the day there were meetings of the International Committee for Testing Cast Iron and the International Committee of Foundry Technical Associations. The Institute of British Foundrymen was represented by Mr. F. K. Neath, B.Sc., at the former, and by Mr. H. Winterton (President) and Mr. V. C. Faulkner (Past-President) at the latter. Mr. V. Delport, President of the London Branch, has been elected President of the Committee, and will be the principal guest at the international conference to be held in Paris next year. Mr. Bannenberg was elected Vice-President. After the meeting, over which Mr. Léonard presided, the delegates dined at the Industrie Club as the guests of their German collegues.

MR. HARRY WINTERTON, in a charming speech, proposed the health of their hosts. He referred to the cleanliness, beauty and splendid lay-out of the city of Düsseldorf, and extended a hearty invitation for everybody to participate in an international congress to be held in London in 1939.

Ein Rheinischer Abend

Friday morning was devoted by most of the British delegates to a visit to the Foundry Exhibition, as language difficulties made technical sessions a little unattractive. This particular problem still requires a good deal of study to arouse real interest for non-nationals. The afternoon was spent visiting the various works which had so kindly thrown open their shops for inspection.

The Zoological Gardens was the rendezvous at night, as the Municipality had invited the whole of the 2,200 delegates to be their guests for the evening. On arrival each guest was given a small programme with four tear-off "food tickets" which entitled the holder to consume four glasses of beer, or wine, or cups of tea or coffee. The huge concert-hall was well filled with tables and an excellent programme of music was provided. The *pièce-de-résistance*, to our mind, was the final item, which apparently is the local counterpart to Auld Lang Syne. From our position in the hall it was fascinating to see wave upon wave of people, first sitting and then standing, joining hands and swaying to the accentuated rhythm of the music.

Moulders' Participation

The exhibition was again well filled on Saturday, but nothing to be compared with Sunday, when 8,000 moulders were marched round the various halls in small regiments. In addition, about 80 foremen came from Belgium.

In the evening there was a visit to the Rokokoschloss—a medieval castle—at Benrath, some seven or eight miles from the town. Here light refreshments were served, whilst an orchestra played "Musik der Zeit." On Sunday morning, at the technical session, Mr. Pearce presented his Paper on the "Structure of Cast Iron" to a large audience, amongst which was

Casting-Consciousness

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but the fact remains that they use substantially similar raw materials, equipment and type of labour. They use the same technique and principles of metallurgy in their production. That they do not enter the same competitive field for business would be an argument for rather than against co-operation, for the question of price fixing has always been the will-of-the-wisp for trade associations. It has appeared to be the one thing bringing firms together, but it has not only led them away into the marshes of extinction, but it has distracted attention from other important matters. It might well be excluded from consideration in associations of the future, although it may have its own provision. In any case, a group of representative associations for the different sections of the industry would have no difficulty in acting together or even in uniting on a national question that concerned all founders. But we have faint hope of any such millenium in this country, although there is every reason why founding should fight for its hand as much as any other process, and castings as much as any other material.

a fair sprinkling of his countrymen. An informal luncheon at the Rheinterrasse brought the proceedings so far as Düsseldorf was concerned to a close.

A special programme had been prepared for the ladies and opportunities were given them to see several of the neighbouring towns and the various castles in the district, as well as to take part in a few trips on the Rhine.

Much private hospitality has been offered by our hosts and many works have been visited which do not figure in the official programme. A few members of The Institute of Vitreous Enamellers, for instance, were very cordially entertained at the only enamelling works—the Rhenania at Schwelm—in the district. No cast iron work is undertaken, but a very high grade of sheet enamelling work is undertaken.

The Exhibition

Without doubt, the foundry exhibitions which the Germans organise from time to time are the finest in the world. In our next issue we hope to give some impressions of the scope and the progress registered at the Düsseldorf Exhibition.

List of British Participants

J. B. Allan (Chesterfield); R. T. Ankers (Manchester); J. Arnott (Glasgow); T. Allen (Birmingham); W. Aston (Dudley); J. H. Booth (Peterborough); G. W. Brown (Birmingham); W. Brunt (Derby); L. W. Bolton (Birmingham); J. Bailey (Wednesbury); W. Beasley (Wednesbury); Mr. Barton (Dudley); J. Cameron, J.P. (Past-President of the Institute of British Foundrymen); and Mrs. Cameron (Kirkintilloch); J. Cameron, jun., and Mrs. Cameron (Kirkintilloch); W. R. Cooper (Wednesbury); J. H. Cooper (Darlington); E. W. Colbeck (Winnington); W. Colman (London); H. B. Clapp (Peterborough); J. J. Collin (Sunderland); F. J. Cook (Past-President of the Institute of British Foundrymen) (Birmingham); Dr. T. B. Crow (Cardiff); W. G. Chapman (Bengal).

V. Delport (Vice-President, International Technical Committee) (London); L. B. Derry (Yeovil); Mr. and Mrs. R. S. Darby (Birmingham); E. C. Dickinson (Coventry); G. Dougill (London); Mr. Evans (Winnington); V. C. Faulkner (Past-President, Institute of British Foundrymen) and Mrs. Faulkner (London); T. H. Gameson (Walsall); Mr. and Mrs. J. Gibb (Newmains); C. J. Grazebrook (Dudley); F. G. Gudgeon (Derby); C. Grice (Luton); G. Hampton (Wednesbury); W. Harper (Willenhall); H. Howarth (Manchester); F. Hargreaves (Eastleigh); R. J. Hird (Glasgow); A. Hodgkinson (Manchester); G. J. L. Howard (Manchester); R. L. Hamilton (Leven).

W. Jolley (Manchester); Mr. and Mrs. Joslin (Luton); Mr. and Mrs. A. L. Key (Manchester); J. Leith (Bonnybridge); Mr. and Mrs. H. Lockwood (London); Mr. and Mrs. Lowen (Sheffield); Mr. and Mrs. E. Longden (Manchester); N. McManus (Glasgow); J. McArthur (Glasgow); A. D. Mackenzie and A. Mackenzie (Glasgow); A. E. McRae-Smith (Dartford); Mr. and Mrs. W. Moscrip (Leven); J. R. McKellar (Glasgow); H. MacNair (Bonnybridge); Mr. Macnab (London); Mr. T. Makemson (Secretary, Institute of British Foundrymen) (Manchester); W. J. Molineux (Wolverhampton); F. K. Neath (Leeds); F. B. Newton, D. D. Newton and R. B. Newton (Manchester); Dr. A. L. Norbury (Birmingham); Dr. H. O'Neill (Derby).

Mr. W. H. Paige (London); Mr. J. G. Pearce (Director, B.C.I.R.A.) and Mrs. Pearce (Birmingham); E. A. Phillips (Grimsby); J. Primrose (Grangemouth); R. V. B. Renwick (Bengal); A. J. Richman (Ipswich); A. G. Robiette (Birmingham); M. Russell (Glasgow); F. Russell (Sheffield); R. H. Smith (South Shields); G. M. I. Shand (London); T. Shanks (Denny); Mr. and Mrs. D. Sharpe and D. Sharpe, jun. (Glasgow); H. H. Shepherd (Ipswich); R. C. Shepherd (Ipswich); Mr. and Mrs. F. G. Starr (Birmingham); J. Shaw (Southsea); Mr. and Mrs. W. Tait (London); G. M. Ure (Bonnybridge).

H. Winterton (President, Institute of British Foundrymen) and Mrs. Winterton (Glasgow); D. H. Wood (Birmingham); H. Wharton (Sheffield); D. Walker (Bonnybridge); J. S. Walton (Port Talbot); F. B. Wilder (Ipswich); and C. Ward (London).

The Lancastria Club

The eleventh banquet of the Lancastria Club was held at the Park Hotel, Düsseldorf, last Saturday evening, under the Presidency of Mr. F. S. Russell. It is rather remarkable that after the ten years of its existence, so many of those who were passengers on the s.s. "Lancastria" in 1926 for the purpose of participating in the first American International Congress, should have been present. The Club is, if anything, more popular than ever. Representatives of about eight nationalities sat down to a truly magnificent banquet, and the following personalities, many of whom are known internationally, participated:—Mr. T. J. and Miss Brons (Holland); Mr. and Mrs. John Cameron and Mr. and Mrs. John Cameron, Jun. (Scotland); Mr. V. Delport (London); Mr. and Mrs. V. C. Faulkner (London); Mrs. Gruson (Germany); Mr. Garrone and Mr. Franco Garrone (Italy); Mr. Juden (U.S.A.); Mr. W. Jolley (Manchester); Mr. and Miss Léonard (Belgium); Mr. and Mrs. E. Longden (Manchester); Mr. Magdelenat (France); Mr. Montupet and his two sons (France); Mr. Otto (U.S.A.); Mr. and Mrs. T. Pangborn (U.S.A.); Mr. and Mrs. Primet and Mr. Primet, Jun. (France); Mr. J. M. Primrose (Scotland); Mr. and Mrs. F. S. Russell (Sheffield); Mr. Guido Vansetti (Italy), and Mr. and Mrs. H. Winterton (Scotland).

(*Concluded from next column.*)

steel partitions that swing from the pipe structure supporting the water pipes. The privacy afforded by these swinging partitions is regarded as extremely important. Shower nozzles discharge against the back walls, so that anyone passing while a shower is in use avoids being splashed. Unit heaters and fan take care of heating and ventilating requirements.

Heating Arrangements

An adjoining room contains a 1,000-gall. hot-water tank and a domestic oil heating unit manufactured by the company. The water temperature is automatically maintained at 180 deg. Fah. at the centre of the tank and is distributed through an automatic mixing valve at 115 deg. In other words, the bather can get water at 115 deg. or cooler according to taste. A time-clock controls the power circuit to the oil burner.

Careful metering of oil, electricity and water discloses that the average cost of heating 1,000 galls. of water to 115 deg. Fah. varies from 1s. 2d. to 1s. 4d., depending on the season of the year.

In the same room are two clothes driers, four wash-tubs, and two wringers. The driers are 4 ft. wide, 6 ft. high and 9 ft. deep, and have a rolling frame to which ropes are attached. When the frame is rolled in, the doorway is sealed, and no heat is used. A suction fan mounted at the rear of each drier takes in the air through vents in the door and exhauts outdoors, thereby drying the clothes and at the same time keeping the air in the room fresh and clean.

Better health and morale are among the dividends the management knows it is getting from this effort to provide better working conditions, and it is proud of the appearance of the moulders as they leave for home at the end of the day.

Moulders' Baths

When the provision of modern washing facilities for foundry employees is being considered, the view is sometimes expressed that the moulders and labourers would not bother to make use of the shower-baths after the management had gone to the trouble and expense of installing them. This has not been the experience of the Malleable Iron Fittings Company, of Branford, Connecticut, U.S.A., who recently provided such equipment at their works. The average use of their shower-baths has been more than 85 per cent. Less than five per cent. of the 160 men in the malleable and brass foundries fail to make regular use of the facilities.

Part of this popularity may be attributed to a natural desire for cleanliness, but some of it is certainly due to an intensive educational campaign the firm conducted during the construction period. The high standard of maintenance has also encouraged general use.

An attendant is present at all times when the shower-baths are in use. It is his duty to scrub down the room immediately after the men have bathed. As a result, they know that the shower-baths are just as clean as, and maybe actually cleaner than, the bathroom equipment in their own homes, many of which, indeed, have no bathroom facilities. Bath towels are hired at cost and must be returned within a week.

Shower and locker rooms are housed in a building that had outlived its usefulness for manufacturing purposes. As it is adjacent to the foundry, it was only necessary to build a short connecting passageway. Thus, the building becomes a part of the foundry, yet is isolated from the dust and dirt of foundry operation.

Ventilation of Locker Room

The lockers provided are the largest standard size—15 in. wide, 18 in. deep and 72 in. high—and are set 32 in a double row on a 6 in. cement curb. The doors and bottoms are perforated and the space between lockers and floor is connected to an underground duct of vitrified pipe that runs lengthwise of the room and is in turn connected to an exhaust fan. The fan has a time-limit switch that may be set to operate as much of the time as may be necessary to provide plenty of ventilation. The underground duct is pitched so that any accumulation of dirt or dust may be washed into a drain out in the yard. The result of this ventilating provision is that the locker room smells sweet and clean in the murkiest days of summer. Complete and uniform circulation is ensured by two unit heaters, placed at diagonally opposite corners of the room. Low-pressure exhaust steam is used to heat the air in the winter months. In summer the unit heaters operate as part of the ventilating system.

Locker keys are provided without charge, but if a man loses his key, the new one is charged for. Key and locker numbers do not correspond—for obvious reasons. The attendant has a duplicate set of keys, a master key, and the necessary index chart.

The Shower Room

Next to the locker room is the shower room. It has seven shower compartments and two 54 in. wash fountains. Showers and fountains are separated by a 5 ft. high wall of buff salt-glazed tile. At the entrance to the showers there is a shallow rubber foot bath that holds a strong antiseptic solution (0.25 per cent. hypochlorite). Everyone who uses the showers is required to step into it upon entering and leaving the room. It is the most effective way of guarding against the "athlete's foot" type of skin infection that is so often picked up in locker rooms.

The rear wall of the shower room is tiled. The compartment is divided into stalls by enamelled

(*Concluded in previous column.*)

Scientific Organisation of Works

It was peculiarly appropriate that the Institute of Metals for their first meeting in Paris should have invited Professor P. A. J. Chevenard to deliver the fifteenth autumn lecture, as the Professor's reputation as a metallurgist extends well beyond his native France. Foundrymen will remember that in 1924 he presented to the Institute of British Foundrymen a Paper on the differential dilatometer. Some points from his lecture which was given to the Institute of Metals in Paris last Monday evening are appended.

"In every enterprise," wrote Fayol, "there are always found six groups of essential operations or functions: the technical function, the financial function, the commercial function, the accounting function, the security function, and the administrative function." But in view of the growing complexity and difficulty of the processes of certain industries, and in particular of the metallurgy of special alloys, it becomes necessary to take into account a seventh function which is derived in a way from the first; this is the *scientific function*.

The objective of science in an industrial enterprise can be defined in two words, to *maintain* and to *improve*. To maintain is to assure the regularity of the actual work; this is effected by *control* which prevents deviations in the manufacturing processes, and by *investigations* which probe the causes of the inevitable failures. To improve is to perfect or remodel manufacturing processes and to create new products; it is preceded by *laboratory researches* and by subsequent *works tests*.

The engineer responsible for the scientific function, sometimes called the *scientific director*, has a delicate and complex administrative task. The lecturer describes, as the result of 26 years' experience, the work accomplished in the works of the Société de Commentry-Fourchambault et Decazeville. As a disciple of Fayol he refers to the five fundamental operations of the *administrative doctrine:* foresight, organisation, command, co-ordination, control.

Foresight

The director of a works should prepare them to utilise at an opportune moment any new idea, to satisfy the future needs of customers, and to frustrate the menace of competition; for these reasons he must have *commercial connections* and *scientific foundations*. The scientific director, whose duty it is to prepare these foundations should take into account the four principal operations of foresight:

(1) *Creation of Scientific Equipment.*—The lecturer enumerates the qualities of the apparatus of research and control: accuracy, sensitivity, convenience, robustness, low price, and precision appropriate for the purpose in view. Very often it is advantageous to construct certain apparatus in the works laboratory. For each stage of a process a special apparatus should be used, always in the order of working. The installations should be stable, the erection simple and strong. By using automatic apparatus as far as possible the tests are made more accurate, more rapid, and less costly, errors due to the personal equation are reduced, and the operatives are spared tedious and tiring tasks.

(2) *Collection of Information for Research.*—Subjects for research can arise from five principal sources, *viz.*, difficulties of manufacture, the requests of customers, inventions, unexpected facts observed in the laboratory or the workshops, and, finally, as part of a comprehensive plan of progress. Researches should always be carried out according to the methods of pure science without, however, losing sight of their utilitarian objective. The aim should be not to prepare a simple catalogue of results, but to *establish a theory* as a base of future progress in the works.

(3) *Putting New Processes and New Products into Works' Practice.*—Taking as an example the development of a new alloy having certain desirable properties, the lecturer describes the steps necessary to put its manufacture on a commercial scale. Laboratory and works' scale tests are designed to establish the best conditions for melting, casting, forging, heat-treatment, etc., and these conditions are then summarised in a *standard procedure of fabrication*.

(4) *Establishment of a Personnel.*—Apprentice courses for juniors, advanced courses for the older employees, and conferences between the senior technical staff assist in developing the *scientific idea* in a works, and at the same time result in numerous moral and social advantages.

Organisation

The technical function is preferably divided between the *scientific director* and the *works manager* who work together, under the authority of the managing director, to ensure the smooth operation of the works. The lecturer describes the organisation which ensures unity of direction; the scientific director, responsible for the theory, supplies the *plans* for the engineers of the manufacturing services, but they receive their *orders* solely from the works' manager, who alone is responsible for taking the necessary measures to have them carried out with regularity, for the best use of the personnel and material, for a low cost of production, and for the time of delivery. The scientific work is divided between the workshops where the experimental results are put into practice, the research laboratory, and the testing and control laboratories.

Command and Co-ordination

The scientific director is in charge of the personnel of the research laboratory, but he also exercises a less direct, but none the less important, action on the personnel of the control and testing laboratories and on the personnel in charge of works' tests. He should endeavour, principally by example, to communicate to all a scientific outlook, he outlines the research programmes and works' tests, defines the plan of unity of control, divides the work between the executives, co-ordinates their activities, collates the results, and, with the aid of the works' manager, draws the necessary scientific and practical conclusions.

Control

This problem has two sides, namely, the organisation of the technical control of the manufactures, and the control in its entirety of the scientific function. The sole means of preventing deviations in the manufacture is to enclose it in the grip of a rigid control. This control extends over the primary materials, the accessory products, products in the course of manufacture, the principal factors in the processes of manufacture, and the finished products; it concerns such elementary properties as the thermal expansion and hardness and such complex properties as the resistance to corrosion and the ease of welding. The methods of control should be quantitative, sensitive and accurate, and their results significant; the lecturer describes three types of control apparatus recently built at the Imphy steelworks.

As for the control of the unity of the scientific function, the lecturer insisted particularly on the minute precautions which are necessary to prevent the slow deviation of the technique of tests and the methods of control from the standard procedure.

In conclusion, the lecturer emphasised the solemn yet deep satisfaction that is the reward of the research staff, quoting the following words of Lord Kelvin: "In the pursuit of truth the work is its own reward and allows the scientist to accomplish with joy his daily task."

Book Review

Hutchinson's Technical and Scientific Encyclopædia. In four volumes. Vol I: A—Direction-Finding. Edited by C. F. Tweney and I. P. Shirshov. Published by Hutchinson & Company (Publishers), Limited, 34, Paternoster Row, London, E.C. Price 20s.

Intelligently to review the contents of an encyclopædia, encyclopædic knowledge must be assumed, but no claim to this is made by the reviewer. He possesses certain specialised knowledge and all he can do is to ascertain whether the information imparted in his field of activity is adequate and accurate and then indicate the scope of the work under review. Naturally enough he first turned to the contribution on cast iron, and as indications of tests up to 35 tons per sq. in. are given, naturally he was satisfied, especially as the matter runs to well over two columns. The reviewer then looked up as many metallurgical terms as fall between A and Di, and found that the matter was thoroughly up to date—even case-hardening by beryllium is mentioned, and moreover, adequately proportioned. Normally one does not consult an encyclopædia for material with which one is familiar and it must be assumed that other sections are equally authoritative. Credence is lent to this assumption by the impressive list of experts who have made themselves responsible for the various sections. Dr. Norman Allen, for instance, has contributed to the section on metallurgy. For the scope of the book, a quotation from the dust cover will serve as well as any paragraph the reviewer could compose: "The work covers the whole field of physics, astrophysics, metrology, porology, electrical communication, chemistry, geology [Bentonite, by the way, is missing], mineralogy, crystal structure, radioacitivity, oceanography and geophysics, engineering (civil, mechanical, electrical and mining), navigation, the science of aeronautics, the making of cinema films, the carbonisation of coal, manufacture and dyeing of textiles, including artificial silk, the sources and manufacture of furs, the manufacture, properties and uses of metals, gems, watch and clock making and jewellery, ship construction, fuels, welding, botany and zoology."

The issue of this first volume certainly whets the appetite for those which are to follow, and limited in erudition though the reviewer be, he has sufficient confidence in his judgment to recommend this work as being a useful, modern, reliable and authoritative work of reference.

V. C. F.

Catalogue Received

Tool Steel. Edgar Allen & Company, Limited, of Imperial Steel Works, Sheffield, 9, have again chosen a folder for describing a type of cutter, to which they have given the trade name of Sharpaform. Covered by Patent No. 410,677, a tool has been developed which carries a number of very important claims; and these claims are substantiated by over a dozen testimonials from well-known users. They appear to be logical, and the explanatory matter affords reasoned argument for the success which has attended the marketing of what can be regarded as a relatively new product. The folder is available to our readers on request.

London Iron and Steel Exchange

The management committee of the London Iron and Steel Exchange has arranged for the annual dinner, which was postponed in February owing to the death of King George, to take place on Tuesday, November 10, at the Dorchester Hotel, Park Lane. The Rt. Hon. Walter Runciman, M.P., President of the Board of Trade, will be the principal guest. Mr. C. Bruce Gardner, chairman of the Exchange, will preside.

Measuring and Controlling Pouring Temperatures and Fluidity

By CARL F. JOSEPH

(*Concluded from page 217.*)

Measurement of Fluidity

In studying the effect of pouring temperature, one naturally thinks of its effect upon fluidity and a means for measuring fluidity. For a number of years the writer employed the fluidity test which Saeger and Krynitsky used in their work on fluidity at the Bureau of Standards.

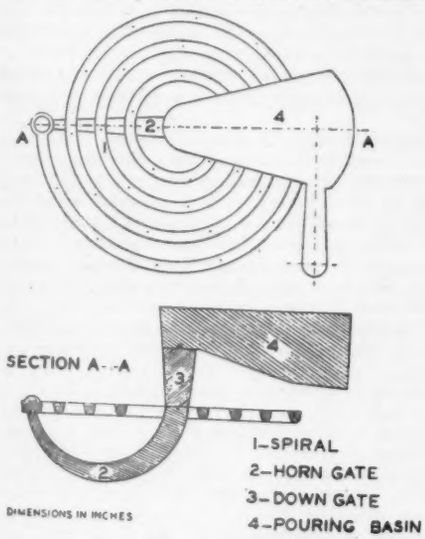

FIG. 4.—ASSEMBLY OF FINISHED PATTERN USED FOR DETERMINING THE RUNNING PROPERTIES OF METAL.

Figs. 4, 5 and 6 show this equipment in detail, which was described in their published work.*

The casting method employed is as follows:—A test ladle holding the proper amount of iron (about 5 lbs.) is poured as rapidly as possible into the pouring basin (4) in Fig. 4, which in turn feeds the metal through the downgate (3) and through the horn gate (2) into the outer end of the spiral (1). By means of the overflow attached to the pouring basin (4) a constant pressure head of molten metal can be maintained. Reference marks are placed at 2-in. intervals along the spiral to aid in determining its length quickly. The total length of the spiral is 60 in. Figs. 5 and 6 show construction details of the fluidity pattern.

The fluidity moulds are made of production green sand and must be prepared as nearly the same as possible each time. Both cope and drag are thoroughly vented.

The fluidity of the iron is affected to a great extent by the variation in ramming and venting of the mould. In the preparation of moulds for the fluidity tests, it was found that the most satisfactory method was to hand-ram and thoroughly vent. Invariably machine jolting and squeezing shortens the length of the spiral by making the mould too hard, and when the mould is jolted and squeezed too little it breaks, therefore hand-ramming is preferred.

No tests were made as to the effect of moisture and permeability of the sand, but the gas pressure developed in that part of the mould not occupied by the metal retards the flow of the iron to a great extent by increased moisture, increased amount of coal dust, and decrease in permeability of the sand. The pouring temperature of the metal can be lowered if all of the factors are favourable.

Determining Fluidity Danger Temperature

Periodically, the fluidity of the iron is checked to determine whether it is possible to pour at a lower temperature. There is a fairly constant loss of heat from the time the iron leaves the electric furnace until the last iron is poured from the pouring ladle. Therefore, if the temperature at which there is a marked drop-off in fluidity is lower, the temperature of the electric furnace can be lowered and *vice versa*. From the temperature-fluidity curve this danger point can be noted and no metal should be poured much under this temperature, otherwise, misruns or cold shuts will occur.

To establish this fluidity danger point accurately it is necessary to average up a considerable number of tests. It has been noted that this drop in fluidity is about 10 deg. C. lower at present than it was a year or two ago. This means that the iron can be heated 10 deg. C. lower in the electric furnace without danger of misruns, providing the drop in temperature in handling the iron remains about the same.

The length of the spiral over a period of time does vary considerably at a given temperature. It is important to study the point at which the length deviates from a straight line when plotting the curve. Usually temperatures are taken at 10 deg. C. intervals.

To get the most consistent results, besides moulding the same each time, the following precautions have been found necessary: The moulds must be thoroughly vented, both cope and drag; this helps to take care of any variation in sand from month to month.

Moulds should be poured as soon after they are made as possible. Those allowed to stand overnight show wide variation in results. The author has tried to pour tests from 50-lb. ladles, but the results were not very uniform until he poured each test individually from a small test ladle.

Method of Pouring Fluidity Tests

About 5 lbs. of iron is taken with a spoon, previously heated, from the transfer ladle. The optical pyrometer is set at 1,480 deg. C. and sighted on the iron in the ladle. When this temperature is reached, the iron is poured into the pouring basin (4), Fig. 4, as rapidly as possible. This is repeated at 10 deg. C. intervals down to 1,410 deg. C. When pouring the iron, it is important to stop when the molten iron runs into the overflow attached to the pouring basin. This ensures a constant pressure head of molten iron. The moulds can be dumped and shaken out a few minutes after being poured and the length of the spiral measured from the reference points which are placed two in. apart. The longest spiral so far poured from white iron is 26 in.

Readings taken three and two years ago showed the results given in Tables I and II respectively.

TABLE I.—*Fluidity Test Reading Taken Three Years Ago.*

Pouring temp. Deg. Fah.	Pouring temp. Deg. C.	Length of spiral in in.
2,720	—	11.25
2,700	1,480	11.0
2,680	—	10.5
2,660	1,460	10.5
2,640	—	8.5
2,620	—	7.0
2,600	1,430	5.5
2,580	—	2.0

TABLE II.—*Fluidity Test Readings Taken Two Years Ago.*

Pouring temp. Deg. Fah.	Pouring temp. Deg. C.	Length of spiral in in.
2,700	1,480	20.0
2,680	—	18.5
2,660	1,460	18.5
2,650	—	13.0
2,620	1,440	10.0
2,590	—	6.0

It will be noted that in both sets of readings the fluidity drops off at 1,460 deg. C. These represent the average of many tests.

Recently on a series of tests the drop in fluidity occurred at a lower temperature, as shown in the data of Table III. It will be noted from these tests that the drop in fluidity occurs at 1,435 and 1,445 deg. C. respectively.

TABLE III.—*Recent Fluidity Tests Ranging from* 1,485 *to* 1,412 *Deg. C.*

"B" unit.		"C" unit.	
Pouring temp. Deg. Fah.	Length of spiral in in.	Pouring temp. Deg. Fah.	Length of spiral in in.
2,710	25.0	2,710	26.0
2,685	19.0	2,685	23.0
2,665	19.5	2,665	22.5
2,640	17.0	2,640	22.5
2,620	17.0	2,620	15.5
2,595	12.0	2,595	15.5
2,575	11.5	2,575	14.5

Moisture Per cent.	Permeability.	Bond. lbs.	Moisture. Per cent.	Permeability.	Bond. lbs.
4.3	50	5.8	4.0	55	6.5

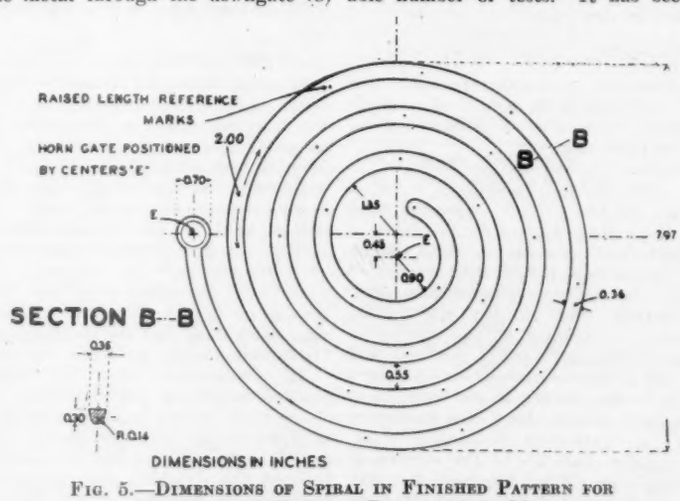

FIG. 5.—DIMENSIONS OF SPIRAL IN FINISHED PATTERN FOR DETERMINING THE RUNNING PROPERTIES OF METAL.

* C. M. Saeger, Jr., and A. I. Krynitsky, "A Practical Method for Studying the Running Qualities of a Metal Cast in Foundry Moulds," Trans. A.F.A., Vol. 39, pp. 513-532 (1931).

During the past four years, the author has used the same standard equipment for checking the optical pyrometers. It might be thought that 10 deg. C. is not within the limit of error of the instruments, but since the average of all results indicates the break in fluidity to

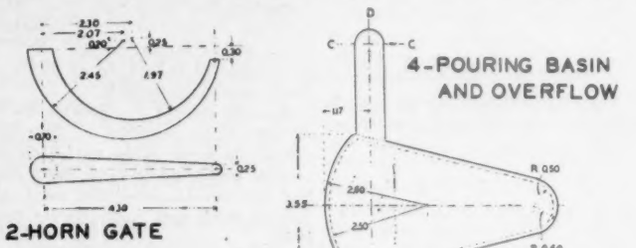

FIG. 6.—DIMENSIONS OF HORN GATE, DOWN GATE AND POURING BASIN IN THE FINISHED PATTERN USED FOR DETERMINING THE RUNNING PROPERTIES OF METAL.

occur between 1,435 and 1,445 deg. C. against 1,445 and 1,460 deg. C. formerly he has been able to hold the iron at a 10 deg. C. lower temperature in the electric furnace with good

TABLE IV.—*Effect of Aluminium on Fluidity.*

Pouring temp. Deg. Fah.	Pouring temp. Deg. C.	Length of spiral in in.
2,700	1,480	24½
2,680	—	19
2,655	—	17¾
2,635	1,445	17
2,610	—	13
2,590	—	10
2,570	1,410	8

results. Aluminium (0.01 per cent.) was added to the iron in a series of spiral tests. The decrease in fluidity occurred about 1,445 deg. C. as shown in Table IV. On iron to which

TABLE V.—*Effect of Copper on Fluidity.*

Plain iron length of spiral in in.	Pouring temperature.		Copper iron length of spiral in in.
	Deg. Fah.	Deg. C.	
23.0	2,685	1,472	20.0
20.5	2,665	—	20.0
21.0	2,640	1,450	19.0
20.0	2,620	—	18.5
16.5	2,595	—	15.0
14.5	2,575	1,412	13.0

0.75 per cent. copper was added, the data of Table V were obtained. The decrease in fluidity occurred on both irons at 1,435 deg. C. regardless of the addition of copper.

TABLE VI.—*Effect of Phosphorus on Fluidity.*

Phosphorus iron. length of spiral in in.	Pouring temperature.		Regular iron, length of spiral in in.
	Deg. Fah.	Deg. C.	
24.00	2,725	1,495	20.0
21.00	2,700	—	18.0
19.00	2,680	—	16.0
16.50	2,655	—	16.5
15.00	2,635	1,445	12.0
14.25	2,610	—	12.0
6.25	2,590	—	12.5
5.00	2,570	1,410	7.0

Ferro-phosphorus was added to the ordinary iron in amounts up to additions of 0.10 per cent.—the ordinary iron being 0.05 per cent. phosphorus. The 0.10 per cent. addition gave the length of spiral as given in Table VI. With this are listed the data for the ordinary iron. The iron to which phosphorus was added shows a break in the curve at 1,428 deg. C. whereas, the plain iron is somewhat higher, although not as distinct as in most of the tests. The phosphorus addition does lower the danger point of fluidity slightly.

Conclusions

It is recommended that foundrymen who are interested in obtaining better operation, give some attention to improving the control of the pouring temperature of their metal. It is true that to maintain accurate control of pouring temperature, a definite programme must be arranged and adhered to in order to obtain the desired results. Most foundrymen recognise that fluidity and pouring temperature are important factors in casting technique and that very little is known about controlling them. Any foundry having a technical organisation will find it an easy matter to instal and maintain pouring temperature control, which should pay good dividends from the very start.

(*Concluded from next column.*)

field of usefulness for re-heating furnaces and soaking pits, particularly as special shapes can be easily moulded *in situ* which will stand a flame temperature of 1,000 deg. C.

Zonolite is also supplied in the form of an exceptionally light weight insulating brick, a standard brick 9 in. by 4½ in. by 3 in. weighing only 1¼ lbs. It is also supplied in the form of insulating panels and specially moulded shapes for the insulation of high temperature steam, oil and pipe lines. In America Zonolite has found a very interesting field in the galvanising industry, where it is applied on the surface of galvanising baths during standby periods, and owing to its inert characteristics and its light weight it floats on the surface of the bath, insulating it at a point where there is a maximum radiation loss and providing a blanket effect, greatly reducing the tendency of the surface of the bath to oxidation. When the bath is ready for working, the Zonolite can be easily scraped to one side or removed altogether. It does not combine in any way with the zinc, neither does it settle to the bottom. Many other uses for the new material will readily suggest themselves, thus for the insulation of the electric furnace it should, owing to its dielectric properties, be particularly well suited. Its possibilities as an insulator against fire, heat and sound are also considerable.

A New Insulating Material

In the foundry, boiler house and, indeed, in every manufacturing process where heat is employed, losses due to radiation have to be taken into consideration; such losses cannot, of course, be wholly eliminated, but they may be kept within narrow limits with an efficient system of insulation. During recent years the question of insulation has certainly received a very great deal of serious attention, but it is equally certain that much still remains to be done. Loss by radiation only represents fuel wasted and adds to the discomfort of the employees. Unfortunately, many insulating materials are purchased on the basis of price per ton and not on a volumetric basis, though obviously it is upon this latter that they are used in actual practice. The price per ton of the material is not of real moment; it is rather the cost per B.Th.U. retained in the plant, in other words, the saving in fuel costs for which the insulation is responsible.

British Zonolite Products, Limited, of London, have recently introduced into this country an insulating material known as Zonolite. Though new to this country, it is a material which has been in increasing use in America for a number of years, where it has been extensively used owing to its exceptionally high thermal insulating, dielectric strength and fireproof qualities.

Zonolite is manufactured from a specially prepared micaceous mineral of the degenerated mica series, which contains a combined moisture content of approximately 8 per cent. The raw material is selected, screened and then infoliated at about 1,100 deg. C. when the moisture of composition is driven off and the material expanded forming a material of trapped air cells in a laminated plate formation. The resultant Zonolite is exceptionally light in weight, the coarse grade weighing only 5 to 6 lbs. per cub. ft., the medium approximately 7 lbs. and the fine approximately 8 to 9 lbs. per cub. ft. A simple calculation will show that the coarse material gives a covering power of 4,500 sq. ft. 1 in. thick per ton.

The thermal insulating properties compare favourably with all the better known insulating materials, whilst the great covering power renders its use more economical. One of the most important uses of Zonolite in the steel trade of America is its application to the open-hearth furnace. It is also extensively used in connection with soaking pits, re-heating furnaces and the like.

A High-Temperature Insulating Cement

In many instances it may be used loose, such, for example, as upon the arches of steel furnaces, but it is also made in the form of a high temperature insulating cement. The two materials used in combination on the open-hearth furnace has shown a saving of approximately 7 per cent. in fuel consumption with 5 per cent. increase in melting rate. In the furnace where these results were obtained the arches had been insulated with loose Zonolite and the side walls, chequer chambers, etc., insulated with the cement. The savings referred to above were direct, but it was also established that the indirect savings such as life of refractories, etc., was very appreciable.

Air infiltration into the furnace through cracked brickwork was eliminated by the use of the cement, a most important factor showing the dual advantage of a material of this type, *i.e.*, saving of heat loss by heat transmission outwards through the structure and the further saving of heat loss by heating up air drawn in through cracks or crevices. The arch life of the furnace was increased by the elimination of constant expansion and contraction, and with the insulation of chequer chambers and so on, higher gas and air temperatures have been obtained, reducing the live gas velocities within the furnace, thereby reducing the erosion of port locks, etc. A material such as Zonolite should find a wide

(*Concluded in previous column.*)

Stainless and Heat-Resisting Iron-Chromium Cast Alloys

The corrosion resistance of iron-chromium alloys increases rapidly at about 13 per cent. of chromium. By adding carbon, however, the resistance of the annealed alloys decreases in proportion to the amount added. This is chiefly due to the formation of chromium carbides (especially Cr_3C_2, which can also take up some iron), which deprive the ground mass of part of the chromium. On the other hand, carbon-containing alloys cast more easily than do the stainless steels. To make full use of the excellent properties imparted by chromium, it is therefore necessary to add a fairly high amount of this element to carbon-containing irons. Alloys of that kind have been investigated by E. Houdremont and R. Wasmuht.* The composition of the irons experimented with is given in Table I.

TABLE I.—*Composition of Corrosion-Resisting Alloys.*

Alloy No.	C.	Si.	Mn.	Cr.
1	1.1	1.3	0.42	33.6
2	2.3	1.4	0.40	34.2
3	3.1	1.2	0.38	34.9

The microstructure of alloy No. 1 consists of a solid solution embedded in the eutectic ground mass. Alloy No. 2 is of nearly eutectic composition, showing only a little solid solution in the eutectic. From this it can be concluded that the ledeburite point which, with straight iron-carbon alloys, is at 4.2 per cent. of carbon, is displaced to about 2.5 per cent. by adding 34 per cent. of chromium. It was found that silicon acts in the same sense, whereas austenite forming elements, such as manganese and nickel, displace the ledeburite point to higher carbon contents. The microstructure of alloy No. 3 consists of solid solution (complex iron-chromium carbide) embedded in the eutectic ground mass. In spite of the great difference in carbon content, the melting points of the three alloys do not differ much from each other. That of alloy No. 2 was found to be at 1,278 deg. C.

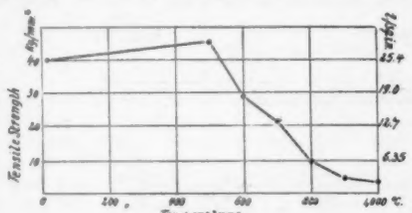

FIG. 1.—TENSILE STRENGTH OF ALLOY NO. 2 AT ELEVATED TEMPERATURES.

TABLE III.—*Properties of High-Chromium Alloys.*

Alloy No.	Transverse strength, tons per sq. in.	Deflection, in.	Tensile strength, tons per sq. in.	Brinell No.
1	32.6	0.201	24.9	250
2	34.6	0.232	27.5	300
3	33.4	0.228	29.5	350

Against atmospheric corrosion the alloys in the as-cast condition behave as follows: No. 1 fully resistant, No. 2 somewhat less, No. 3 non-resistant, the casting skin showing rust spots. With a finely-ground surface all the three alloys prove fully resistant. The resistance of alloys Nos. 1 and 2 against the attack of various chemical re-agents is shown in Table II. The two alloys also prove heat-resistant up to 1,100 deg. C. The shrinkage allowance is 1.6 to 1.8 per cent. The specific gravity of alloy No. 1 is 7.42, of No. 2, 7.34.

From Table III it can be seen that the tensile strength is nearly twice as high as that of ordinary cast iron. A noticeable elongation does not exist. The hardness increases with increasing carbon content. Fig. 1 shows the tensile strength of alloy No. 2 at elevated temperatures. The thermal expansion of the alloys is of the same size as that of wrought iron but smaller than with cast iron. It takes place very uniformly because the alloys do not undergo any structural changes. This eliminates distortion of castings which have to sustain high temperatures. For the same reason no heat-treatment is required after working the alloys.

Machining takes a somewhat longer time than in the case of cast iron, but no trouble is usually encountered. In turning it is advisable to take a heavy cut at a relatively low speed. In most cases, a good high speed steel will suffice, in special cases Widia tools must be used. The alloys can be easily welded both by fusion and electricity. Heating and cooling, however, must be carried out with great care, otherwise cracks will appear near the weld. By a special treat-

(*Concluded on page* 240.)

TABLE II.—*Behaviour of Corrosion-Resisting Alloys.*

Chemical reagent.	Temperature, deg. C.	Degree of resistance* of alloy. 1.	2.
Nitric acid, HNO_3:			
7 per cent., sp. gr. 1.04	20	I	I
	Boiling	I	I
37 „ „ 1.23	20	I	I
	Boiling	II	II
66 „ „ 1.40	20	I	I
	Boiling	II	II
Concentrated, fuming, sp. gr., 1.52	20	II	II
	40	V	V
Mixed acid:			
30 per cent. by weight H_2SO_4 conc. + 5 per cent. HNO_3 conc. + 65 per cent. water	50	I	I
Sulphurous acid, SO_2:			
Saturated aqueous solution	20	I	II
Phosphoric acid, H_3PO_4:			
10 per cent., sp. gr. 1.05	Boiling	I	I
45 „ „ 1.30	„	I	I
80 „ „ 1.64	„	IV	V
Acetic acid, $C_2H_4O_2$:			
10 per cent., sp. gr. 1.01	Boiling	I	I
80 „ „ 1.07	„	I	I
100 „ „ 1.05	„	I	I
Lactic acid, $C_3H_6O_3$:			
1.5 per cent.	Boiling	I	I
Caustic soda, NaOH:			
15 per cent. aqueous solution, sp. gr. 1.16	50	I	I
	Boiling	I	I
50 „ „ „ „ 1.53	„	V	V
Ammonium nitrate, NH_4NO_3:			
50 per cent. aqueous solution	Boiling	I	I
Ammonium sulphate, $(NH_4)_2SO_4$:			
50 per cent. aqueous solution	Boiling	I	I
Calcium bisulphite, $Ca(HSO_3)_2$:			
Aqueous solution saturated cold, pressure 170 to 215 lbs. per sq. in.	~ 150	V	V
„ „ „ „ „ 57 to 85 „ „	~ 90	I	I
Calcium hypochlorite, $Ca(OCl)_2$:			
Aqueous solution, saturated cold	40	II	II
Ferric chloride, $FeCl_3$:			
30 per cent. aqueous solution	20	V	V
Saltpetre, KNO_3:			
25 per cent. aqueous solution	Boiling	I	I
Sodium sulphide, $Na_2S + 9H_2O$:			
50 per cent. aqueous solution	Boiling	I	I
Zinc chloride, $ZnCl_2$:			
Aqueous solution, sp. gr. 1.20	Boiling	I	I
„ „ „ 1.90	„	V	V

* Degree of resistance.	Loss in weight, grams per hr. per sq. m.
I fully resistant	0 to 0.1
II sufficiently resistant	0.1 „ 1.0
III fairly resistant	1 „ 3
IV little resistant	3 „ 10
V non-resistant	Over 10

* "Die Giesserei," Vol. 19 (1932), Nos. 33-34, pp. 322-325.

D

Copper and Copper-Manganese Grey Cast Iron

By L. W. EASTWOOD, ARTHUR E. BOUSU, and C. T. EDDY*

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Introduction

This Paper summarises a manuscript dealing with the investigation into the use of copper in cast iron which was undertaken in the regular research programme of the Michigan College of Mining and Technology and, during the past year, under the co-operative research programme sponsored by the Federal Emergency Relief Administration.[1] It is a presentation of correlated data on the effects of copper in grey iron and a discussion of the properties of these alloys.[2]

A casual consideration of the complexity of cast-iron alloys, and of the importance of the many factors affecting the properties of cast iron, is sufficient to account for many of the discrepancies in work reported by numerous independent investigators in the literature. In view of this, the present investigation has been based upon a comprehensive plan which, in the study of the effect of copper, permits the control of the several variables of primary importance to the ultimate properties. Thus, the effect of copper on both dry and green sand castings was studied with controlled variation of silicon, carbon and manganese and with the other important factors held as constant as possible.

Present Investigation

The present investigation began in 1932. The initial programme was described in an article[3] which qualitatively discussed the general results obtained up to the time of publication. The scope of the project was later increased by the replacement of a 12-in. cupola with a 21-in. furnace having a capacity of approximately 1,800 lbs. per hr.

Obtaining a Suitable Base-Iron.—To obtain a uniform base-iron to which alloy additions could be made, a receiver was constructed and lined to a 21-in. inside diameter. A refractory lined cast iron cover was provided with a 4-in. opening to permit alloy additions to be made and to receive a high-pressure oil-burner which was used to preheat the receiver. Before the cupola was tapped, the burner was removed and the cover luted tightly into place.

Because the first charge was not as hot as the succeeding ones, scrap alone was used in it, the charge being tapped into the receiver and removed after a few minutes, just before the regular charge was tapped. About 800 to 900 lbs. of the regular charge were then collected in the receiver, the cupola was closed down, and 5 or 6 taps were taken from the receiver with the various alloy additions made to each tap. A set of test-bars was cast from each tap, the temperature of which was obtained by sighting a Leeds & Northrup optical pyrometer on the stream of iron tapped from the receiver. A second reading was made on the iron when the moulds were poured. Since there was some temperature drop in the receiver, quadruplicate heats were made, two with copper added to the receiver, thus causing the copper content to increase with slightly decreasing casting temperature. In the other two heats, the copper was added to the ladle; the largest addition was made to the first tap, causing the copper content to decrease with slightly decreasing casting temperature. Thus each method of making the alloy addition was carried out in duplicate. This procedure was adopted to make possible the study of the effect of the slightly decreasing casting temperature.

Base-Irons of Various Carbon and Silicon Contents.—To determine the effect of copper in base-irons of various carbon and silicon contents, the following six types of charges were used, each being run in quadruplicate:—

Type of charge.	Steel, per cent.	Grey iron scrap, per cent.	Pig-iron, per cent.	Si, per cent.
A	30	20	50	1.30
B	30	20	50	2.20
C	30	20	50	3.30
D	75	25	0	1.75
E	60	23	17	1.50
F	60	23	17	2.15

Group *C* contains somewhat higher silicon than most commercial grey irons. It was thought at the beginning that copper might overcome some of the undesirable features produced by high silicon, but this possibility was not fulfilled. However, this high-silicon iron, though of no probable commercial value, definitely has made it possible to substantiate the relationships of silicon to copper which were found in the lower silicon irons containing 1.3 and 2.2 per cent. silicon.

It will be noticed that the base-iron contains a small amount of copper even though great care was exercised to keep it a minimum. Several probable sources of this copper are: (1) small amounts of copper frequently contained in local grey iron scrap; (2) copper absorbed from the linings of the furnace, fore-hearth and ladles; and (3) copper on the drill steel.

The most convenient size of local steel scrap is drill steel from the Upper Peninsula copper mines. This drill steel is hollow, and the mine water contains enough copper to plate out, principally on the interior of the steel where it would be less likely to be removed by wear entailed in the drilling operation and in handling.

The manganese was kept as constant as possible, 0.55 to 0.70 per cent., through the addition of spiegeleisen to the charge. The silicon content was controlled by using various grades of pig-iron and by adding ferro-silicon to the charge. Because of the unavoidable differences in the composition of small charges, the silicon and manganese contents vary somewhat from the calculated percentages. The carbon content of the grey iron varied with the amount of carbon in the charge and with the silicon content, the latter tending to retard the carbon absorption in the cupola. The interval between successive cupola taps, about six minutes, was held as constant as possible to keep carbon absorption nearly constant.

Because of the relatively low carbon content of the type of charge represented by group *D* and the consequent lower melting rate of the charge and higher solidification temperature of the resulting iron, the receiver was not used, but instead, a 300-lb. ladle into which enough iron was tapped to cast two sets of test-bars. The ladle additions were made and the process was twice repeated, producing six sets of test-bars. A smaller ladle was used to pour the moulds, the ladle addition being made in such a way that the quantity of copper addition was reversed, each method of addition being done in duplicate. Thus, the charge was run in quadruplicate, as were the others. The analyses of group *D* show that there was some variation in the analysis of the base-iron. This was unavoidable, however, because of the difficulty of keeping this particular iron sufficiently hot for as long as 50 minutes, the time from the first cupola tap to the last receiver tap.

The results here reported were obtained from four or more heats for each base-iron using six different irons of widely different compositions. These results will show that the conflicting nature of much of the data reported heretofore results from unduly general conclusions based on a very few heats having a very limited range in composition.

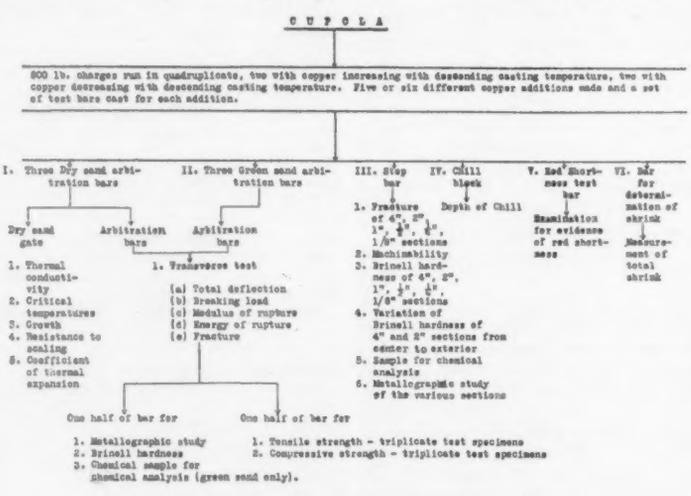
CUPOLA
800 lb. charges run in quadruplicate, two with copper increasing with descending casting temperature, two with copper decreasing with descending casting temperature. Five or six different copper additions made and a set of test bars cast for each addition.
I. Three Dry sand arbitration bars
II. Three Green sand arbitration bars
III. Step bar
IV. Chill block
V. Red Shortness test bar
VI. Bar for determination of shrink
Dry sand gate
Arbitration bars
Arbitration bars
1. Thermal conductivity
2. Critical temperatures
3. Growth
4. Resistance to scaling
5. Coefficient of thermal expansion
1. Transverse test
(a) Total deflection
(b) Breaking load
(c) Modulus of rupture
(d) Energy of rupture
(e) Fracture
1. Fracture of 4", 2", 1", ½", ¼", 1/8" sections
2. Machinability
3. Brinell hardness of 4", 2", 1", ½", ¼", 1/8" sections
4. Variation of Brinell hardness of 4" and 2" sections from center to exterior
5. Sample for chemical analysis
6. Metallographic study of the various sections
Depth of Chill
Examination for evidence of red shortness
Measurement of total shrink
One half of bar for
One half of bar for
1. Metallographic study
2. Brinell hardness
3. Chemical sample for chemical analysis (green sand only).
1. Tensile strength - triplicate test specimens
2. Compressive strength - triplicate test specimens

FIG. 1—OUTLINE OF TESTING PROCEDURE.

Test-Bars

The test-bars cast consisted of (1) three bars, 1.2-in. diameter and 21-in. long cast in green sand, (2) three bars of the same dimensions cast in dry sand, (3) a step bar cast in green sand, (4) a chill block, (5) a bar to determine red shortness, and (6) a bar to determine total shrinkage. The outline of testing these bars is shown in the diagram, Fig. 1.

Each heat was numbered, each test-bar being marked with this number and a letter, *A* to *E* or *F*, the *A* indicating the first set of test-bars

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1 The complete original manuscript may be obtained in mimeographed form for the cost of preparation, upon application to the Michigan College of Mining and Technology. It includes an historical summary and complete data in tabulated and graphical form together with photomicrographs. It further includes a careful study of the iron-copper and the iron-copper-cementite equilibrium diagrams in the light of previous investigations.

2 For an historical review, a critical discussion and a bibliography consult original manuscript (see Note 1) and Gregg, J. L., and Daniloff, B. M., "Alloys of Iron and Copper," Alloys of Iron Monograph Series, McGraw-Hill Book Co., New York (1934).

3 Eddy, C. T., "Copper in Grey Cast Iron," "The Foundry," Vol. 62, No. 2, February, 1934, p. 15.

to be cast, and the last letter indicating the last set to be cast. The dry-sand bars were given another letter, *D*, to indicate dry sand; the 1.2-in. diameter green-sand bars were given a letter *G*. Thus, 36*CG* indicates heat 36, and a green-sand bar of 1.2-in. diameter from the third set of test-bars cast. The analyses of the green-sand and dry-sand bars of the same set have the same composition.

Methods of Casting Bars and Making Tests

The three green-sand bars of arbitration-bar dimensions were cast horizontally. The pattern with gates and runners was mounted on a match board. The dry-sand bars were cast vertically and gated at the bottom as shown in Figs. 2A and 2B. The gate, ¾-in. in diameter, was saved for the purpose of determining thermal conductivity, coefficient of expansion, critical points, permanent growth, and resistance to scaling. The three dry-sand bars and the three green-sand bars were broken by transverse loading with an 18-in. span. From one of the halves of each bar, a standard tensile specimen and a compression specimen, 0.8-in. in diameter and 2.4-in. long, were machined. Hence, these specimens were tested in triplicate.

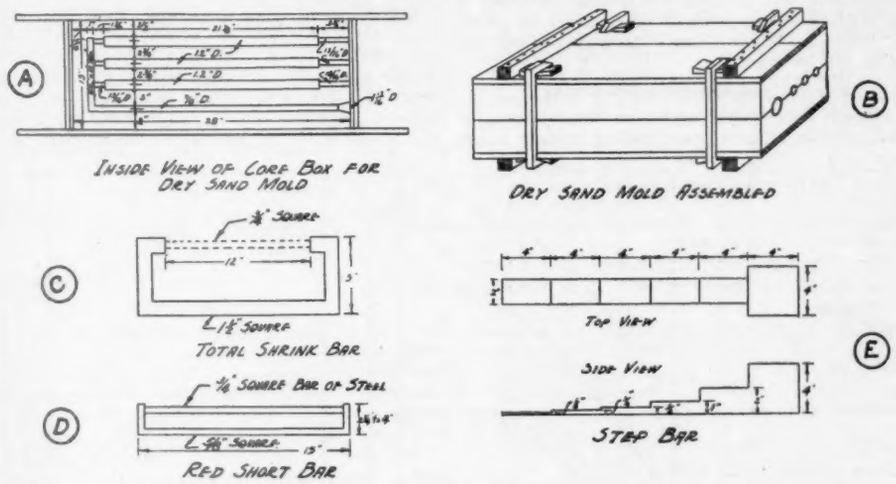


Fig. 2.—(A) and (B)—Method of Moulding Test-Bars. (C)—Total Shrinkage of Bar. (D)—Bar for Testing Red Shortness. (E)—Step Bar.

At the beginning of the testing, the other three halves resulting from the transverse test were broken in impact, using an Amsler impact machine and an 8-in. span. This test was discontinued because the energy of rupture by the transverse test gave a better and more uniform indication of the brittleness than the energy of rupture by impact. This conclusion is based upon the fact that the energy of rupture by impact and the energy of rupture in transverse bending were similarly affected by the copper addition, thus showing their relationship and interdependence. The interdependence is natural, for each is a measure of the toughness of the iron. Because of the greater uniformity of the energy of rupture in the transverse test, this measure of the toughness of the iron was selected as being more satisfactory than that obtained by the impact test.

Total shrinkage was determined by casting a bar, as shown in Fig. 2C, between chills, 12 in. apart, and measuring the difference in length of the resulting bar and the length between chills.

Since copper is reported to cause red shortness, which would be a serious limitation if true, the possibility of such a characteristic was investigated by casting a clamp-shaped bar as illustrated in Fig. 2D. The piece of steel was inserted between the jaws of the clamp in such a position that the end of the steel bar and the clamp were in contact, thus preventing shrinkage. The strain at the corners of the hot iron should cause failure by cracking if the copper bearing iron were hot short.

The step-bar, illustrated in Fig. 2E, was designed to give information on the effect of copper upon the formation of free cementite, and upon the fracture and hardness of the various sections. The 4-in. sections and the 2-in. sections were cut through the centre to permit an investigation of the variation in hardness from the centre to the exterior of the section. The chill blocks, 4-in. long, 2-in. high, and 1-in. thick, were cast on edge on an iron chill. After cooling, the blocks were broken in two parts and the depth of chill was measured.

Chemical Compositions

Chemical compositions of the irons tested are based on analyses of two sets of samples, one taken from the 1.2-in. diameter green-sand bar and the other from the 2-in. section of the step-bar. When casting, the step-bar was poured first, the dry-sand bars second, the 1.2-in. diameter green-sand bars third, the red-shortness bar and the total shrink bar fourth, and the chill block last. Hence, the samples for chemical analyses were taken from two portions of the iron in the same ladle, one from the first iron poured and the other from the iron poured from the last portion of the metal.

Methods of Adding Copper to Cast Iron

There are several methods of adding copper to cast iron:

(1) Direct addition of copper ingots or other suitable forms to the cupola, either as pigs added directly with the charge or enclosed in cast iron. This method has the advantage of simplicity. However, behaviour in the cupola and the losses have not been sufficiently investigated.

(2) The melting of copper bearing scrap in the cupola. At least part of the copper can be added in this manner, as no difficulty from melting copper-bearing grey iron scrap was experienced.

(3) The addition of copper turnings or shot, cold or heated, to the iron issuing from the spout when tapping the cupola. Copper melts at 1,083 deg. C. and, as compared with nickel, it melts readily and is quickly dissolved by the iron. Under the usual conditions, at least 1.5 per cent. of copper can be added by dropping copper shot into the tapped stream of iron. The maximum amount of copper which can be added depends upon the temperature and composition of the iron tapped from the cupola and the minimum permissible casting temperature. Three per cent. copper has been successfully added by tapping the heat into a small ladle in which 25-lb. copper ingots were placed. The ladle was held at such an angle that it continuously poured into the larger receiving ladle. The copper was thus dissolved by the hot metal and washed into the forehearth or receiving ladle, the agitation due to the pouring assuring uniform mixture.

(4) Addition of copper in the molten state to the iron as tapped from the cupola. This method is the best when high percentages of copper are added to the iron.

(5) Addition of copper in the form of a copper-silicon alloy, either cold, hot or molten. When copper is melted with 90 per cent. grade ferro-silicon to form an alloy containing 8 to 15 per cent. silicon, the resulting alloy melts at 800 to 850 deg. C., as compared with 1,083 deg. C. for pure copper. This alloy is readily dissolved, forming a uniform alloy cast iron. Of course, the added silicon must be taken into consideration. This method yielded excellent and uniform results, but because of the added variable, silicon, this type of alloy addition is not suitable for research.

(6) Addition of copper in the form of a copper-manganese alloy, either cold, hot or molten. When standard ferro-manganese is added to molten copper, the ferro-alloy dissolves and the graphite liberated forms a "kish." The resulting alloy, when containing 20 to 45 per cent. manganese, melts at 875 to 925 deg. C., and is also ideal for alloying additions. High manganese-copper grey iron was investigated in the research project here reported. In some instances, when the manganese was added to the cupola and the molten copper to the tap, the iron was found to be unsound. However, when the molten copper-manganese alloy, containing about 35 per cent. manganese, was added to the ladle or forehearth, the resulting alloy cast iron was both uniform and sound. The alloy addition must be made to the ladle or forehearth with simultaneous stirring to avoid settling to the bottom and consequent difficulty of solution.

Plain Copper Grey Iron

The various properties have been plotted against the copper content for all of the heats, being grouped in accord with the six base mixes used. For the purpose of this summary, however, the resulting number of figures was prohibitive, and Fig. 3 is given merely to indicate the general nature of the influence of copper on the properties concerned. It is obviously not a rigorous representation, nor can such be derived from the data for several reasons; small inconsistencies in the properties, variations in analysis (in quadruplicate heats) because of the difficulty of obtaining small charges of the same composition, and deliberate and statistical variation in foundry technique (additions made on rising temperature, on falling temperature, to the forehearth, to the ladle, etc.). For the purpose of comparison, the data from one heat, picked as representative of each group, are plotted in dashed lines on the same co-ordinates (Fig. 3). Because the beneficial effects of copper in high-silicon irons are minimum and because erratic results were obtained in the testing of these irons, the curve for group *C* is omitted from Fig. 3.

Hardness

Fig. 3C shows the increase in hardness incident to the addition of copper. This is about 30 to 60 points Brinell, the increase being somewhat greater for the lower-silicon and the lower-carbon irons, the silicon having the greater influence. When the silicon is high, as represented in group *C*, the results are erratic and the improvement of hardness is a minimum. The lower-carbon series, represented by groups *D*, *E*, and *F*, contain copper up to 5.5 per cent. with gradually increasing hardness. This shows that the effective-hardening copper—*i.e.*, that in supersaturated solution or as submicroscopic particles—can be present to the extent of 5.5 per cent. However, the maximum rate of increase in hardness occurs up to 3.0 per cent. copper, after which it slopes off to some extent.

The study of the effect of copper on the Brinell hardness of the 1.2-in. diameter round bars reveals that when the silicon is approximately 1.3 per cent., each per cent. of copper up to 3.0 per cent. increases the Brinell about 18 points, but if the silicon is about 2.25 per cent., the increase is about 14 points. This relationship is about the same for both the dry-sand and green-sand bars. At the beginning of this research, it was thought that copper might offset the adverse effects of high silicon. The hardness data show that copper does not markedly harden the high-silicon base-iron represented by group *C*. It will be observed later that copper also does not improve the other properties of this high-silicon iron.

The relation of copper content to the Brinell hardness of the 4-in. sections of the step-bar is given in Fig. 3. The 4-in. sections were cut in half through the centre and the Brinell hardness was obtained at each ½-in. interval from the centre to the outside. The same relationships observed previously concerning the 1.2-in. diameter bar apply also to the hardness of the 4-in. sections, the principal difference being that the increase in Brinell hardness for each per cent. of copper is 2 or 3 points less than that for the smaller 1.2-in. sections—the hardness of the 4-in. section being taken 1 in. from the centre.

The increase in Brinell hardness with increasing copper content, the influence of section size, silicon, and carbon contents on the amount of this increase, are further substantiated by the Brinell hardness of the 2, 1, ½ and ¼-in. sections of the step-bar cast in green sand. The hardnesses of these sections are given in the original Paper and are not graphically represented.

The extensive determination of the Brinell hardness in sections of various sizes, as well as the investigation of the hardness from the centre to the exterior of the 4-in. and 2-in. sections, has made it possible to determine the influence of section size in copper-bearing grey iron. The differences in hardness of the 4-in. and ½-in. sections were plotted against copper content. These curves, not presented in this summary, indicate that copper slightly increases this difference in hardness of the large and small sections (as much as 5 to 10 points Brinell at 3.0 per cent. copper in the low-silicon iron, groups *A* and *E*, and about 10 to 15 points Brinell in the higher silicon irons).

There is always some increase in hardness of large sections from the centre to the exterior. When the difference in hardness of the interior and exterior of the 4-in. sections is plotted against the copper content, it is found that copper neither increases nor decreases this variation in any of the six base-irons. Thus, copper does not materially affect the uniformity of hardness within a given section.

Transverse Strength

The relation of breaking load to copper content of the 1.2-in. diameter bars cast in green sand is shown in Fig. 3D. The green-sand bars were broken in the same position in which they were cast. It is evident that copper has a slightly adverse effect upon the breaking load of all six types of base-iron; this decrease is slightly greater in the green-sand bars, amounting to 100 to 200 lbs. at 3.0 per cent. copper. The breaking load of the higher-silicon and lower-carbon dry-sand bars is not adversely affected by the copper up to 3.0 per cent. (groups *B*, *D*, *E* and *F*).

The increase in hardness caused by the copper is reflected in lower deflection values for both dry-sand and green-sand bars in all six groups, though the highest strength iron, group *D*, is not affected adversely to any noticeable extent. The copper does not improve the results for irons of the highest silicon content represented by group *C*. These heats gave inconsistent results and are uniformly inferior.

Tensile and Compressive Strength

The effect of copper upon the tensile strengths and upon the corresponding compressive strengths of the green-sand and dry-sand bars is illustrated in Figs. 3A and 3B respectively. The increase in tensile strength is very marked in some of the compositions, being greatest in the green-sand bars of low silicon content. The tensile strengths of the high-silicon irons are not improved by the copper addition. As shown in Fig. 3B, the compressive strengths of all except the very high silicon irons are very markedly improved. The maximum increase in compressive strength occurs in the low-silicon iron.

Total Shrinkage.—Contrary to many published reports, the total shrinkage, as definitely shown by a great many determinations, increases slightly with increasing copper for all six groups of base-iron. This increase in total shrinkage is not large, however, being about 0.007 in. per ft. for each per cent. of copper up to 3.0 per cent.

Influence of Copper on Chill

Scores of determinations clearly show that copper has no influence upon chill when silicon is higher than 2.0 per cent., as in groups *B*, *C*, and *F*. There is a very slight tendency to increase chill in these irons when the copper exceeds 3.0 per cent. On the chill blocks used in this investigation, this slight increase is not more than $\frac{1}{16}$ in. for each per cent. of copper above 3.0 per cent.

When the silicon is about 1.75 per cent. with low carbon, as in group *D*, each per cent. of copper up to 3.0 per cent. reduces the chill about $\frac{1}{16}$-in. on the chill block 4-in. long, 2-in. high, and 1-in. thick, cast on edge. Copper above 3.0 per cent. in this iron has a tendency to increase the chill slightly—about $\frac{1}{16}$-in. for each per cent. of copper.

When the silicon is 1.25 to 1.50 per cent., as in groups *A* and *E*, copper up to 4.0 per cent. reduces chill markedly, this decrease being about ½-in. for each per cent. of copper up to 3.0 per cent. In group *E*, when the copper exceeds 4.0 per cent., there is a slight increase in chill. Thus the influence of copper on chill is determined principally by the silicon content, a fact which explains many of the contradictions in the published data on this subject.

Tendency of Copper to Prevent Chill in Small Sections

This effect of copper is closely related to its influence upon chill produced upon the chill block and, as might be anticipated, the effects are parallel. The step-bar described previously clearly shows the effect of copper upon the tendency of the iron to chill in small sections. This step-bar contains six sections, each 4-in. long and ⅛, ¼, ½, 1, 2, and 4-in. thick. The first five sections are 2-in. wide, and the last is 4-in. wide. The small sections tend to chill, the tendency to chill being manifested in the greater distance that the white iron extends up the bar toward the heavier sections. When referring to the amount of chill, the length of section totally white, measured from the tip of the smallest end, will be given.

Low-silicon iron containing moderately high carbon, as represented by group *A*, has less tendency to chill in small sections when copper is added, this decrease being from 3 in. of white iron at 0.0 per cent. copper to 1.5-in. at 3.0 per cent. With similar silicon content but lower carbon, as represented by group *E*, the length of white iron is reduced from 3.7 to 2 in. for the same copper range. Above 3.0 per cent. copper in this latter group, the length of chill is increased again, until at 4.5 per cent. copper, it is about the same as at 0.0 per cent.

When the silicon is near 2.0 per cent., as in groups *B*, *D*, and *F*, the copper does not affect the length of chill up to about 3.0 per cent. copper, but above this amount it tends to increase the chill slightly in the small sections. When the silicon is very high, as in group *C*, the copper has no influence up to 1.0 per cent., but above this amount it increases the chill markedly, the chill being nothing at 0.0 per cent. copper and 1.25 in. of white iron at 3.0 per cent. copper.

The graphitisation in small sections is an important factor, since it eliminates the hard spots

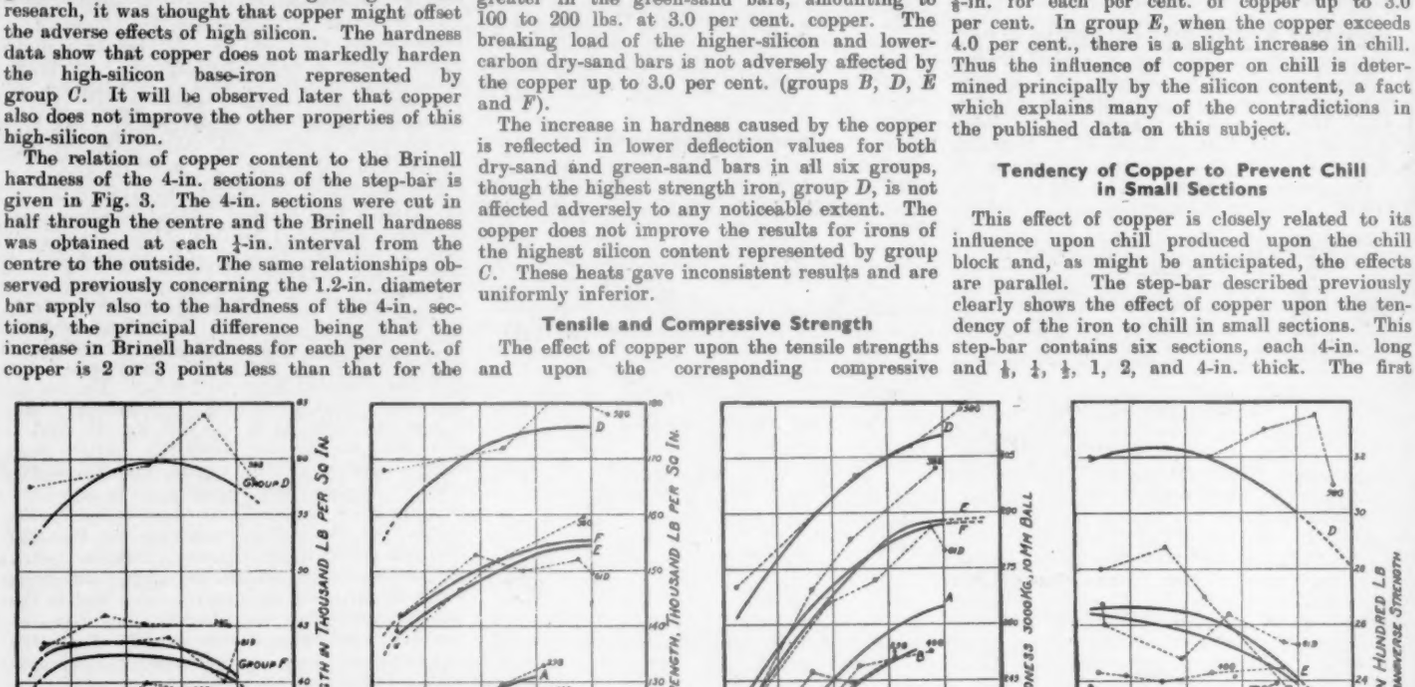


FIG. 3.—INFLUENCE OF COPPER ON GREY CAST IRON. (A)—TENSILE STRENGTH. (B)—COMPRESSIVE STRENGTH. (C)—BRINELL HARDNESS. (D)—TRANSVERSE STRENGTH.

in the smaller sections of grey iron castings. The influence of copper upon this graphitisation is intimately related to silicon content. Since chill in small sections is naturally most pronounced in irons of low-silicon content, the copper has a marked beneficial effect upon the graphitisation of the cementite in the light sections of such iron.

The Ford Motor Company, in private communication, offers corroborative information as follows: In chilled and grey iron "our percentages of copper vary somewhat, but for the most part run from 0.75 to 1.00 per cent. The copper helps the fluidity of grey iron considerably and acts as a graphitiser. It hardens and tightens up the matrix to such an extent that the so-called 'sponginess' in grey iron is lessened. In castings where there are a number of light and somewhat heavier sections, copper aids greatly in helping (preventing) these light sections from chilling and holds a fine structure in the heavy ones . . . it thus acts as a stabiliser . . ."

The tendency of the combined carbon to increase slightly with increasing copper cannot be considered as evidence that copper retards graphitisation of free cementite. It is well known that the eutectoid cementite graphitises much less readily than proeutectoid or eutectic cementite. Rather, the increase in combined carbon supports the contention of E. Reed[4] that copper increases the carbon content of the eutectoid.

Machineability

The best measure of machineability is a production test, since machineability is dependent upon many factors. Among them the most important is the presence of free cementite. Such hard particles are very detrimental. Therefore, increased hardness may not mean increased machining difficulties unless the increased hardness is due to free carbides. Since it has been observed that copper causes graphitisation in low-silicon iron, it is reasonable to expect that copper would increase the machineability of small sections in such iron, though production tests have not been run for the purpose of substantiating this belief.

Red Shortness

Because the occurrence of red shortness in copper-bearing grey cast iron would be a serious limitation, and because increased red shortness has been attributed to copper, this characteristic has been very carefully studied. The clamp-shaped test-bar, illustrated in Fig. 2D, was cast with each set of test-bars, the length of the arms of the clamp being 2¼, 3¼, or 4 ins. The shorter the arms, the greater the strain at the corners and the greater the likelihood of failure in the mould. The steel bar was always cast in contact with the arms of the clamp, so that shrinkage in the distance between the arms of the clamp was completely prevented. It was found that the copper-bearing iron never failed when the length of the arms was 4 ins. When the length was reduced to 2¼ or 3¼ ins., the copper-bearing iron failed no more frequently than the plain iron. The absence of red shortness in the copper-bearing iron is in conformity with the fact that copper, in the ordinary amounts used in grey iron, does not form a part of a network structure of any kind, the copper being in solution in the austenite at high temperatures.

Amenability to Precipitation Hardening

A consideration of the constitution diagram of the iron-copper-carbon alloys indicates a marked decrease in solubility of copper in the solid state, from about 5.0 per cent. (depending upon the carbon content) at high temperatures to a very few tenths of 1.0 per cent. at room temperature. The decrease in solid solubility is ideal for precipitation hardening. The temperature used for precipitation was 500 deg. C., since this temperature was found by Cyril S. Smith[5] to be suitable for the precipitation hardening of copper-bearing malleable cast iron.

To investigate the amenability of the copper-bearing grey cast iron to precipitation hardening, the ⅞-in. bars used in the red shortness test and the 4-in sections of the step-bar of the following heat were selected for testing.

No.	Analysis.			Brinell.	
	Si, per cent.	Mn, per cent.	Cu, per cent.	Original ⅞-in. section.	Step-bar 4-in. section.
61*A*	2.14	0.66	3.76	312	248
61*C*	2.25	0.65	2.76	308	246
61*D*	2.22	0.60	1.91	305	239
61*F*	2.17	0.67	0.48	265	213

After heating for 1, 2, 4, and 6 hrs. at 500 deg. C. none of the 4-in. sections could be increased in hardness, this property remaining practically unchanged. The small sections of 61*A* and 61*C* were increased 13 points Brinell at the end of 2 hrs., while the other two samples, 61*D* and 61*F*, were practically unchanged. It is reasonable to suppose, therefore, that copper-bearing grey iron is not amenable to precipitation hardening, except when the section is small and the copper content above 3.0 per cent. The small section apparently is necessary because of the more rapid cooling which maintains the copper in supersaturated solution. It is thus improbable that the precipitation hardening of plain copper grey iron will ever be of much importance. A normalising treatment at a temperature just under the $Ac_{2,1}$ point was not tried prior to an ageing treatment. Because of complications, such a treatment would cause other changes in addition to its effect on the condition of the copper.

Microstructure and Fracture

All of the six sections of the step-bars from heats Nos. 27 and 38 were examined to determine the effect of copper upon the size, shape and distribution of graphite flakes. In the relatively high-carbon, high-silicon heat No. 27 (2.5 per cent. silicon), there was a slight, though not marked, progressive refinement of the graphite flakes in all of the sections which were grey. However, when the silicon is lower (1.35 per cent.), as in heat No. 38, the copper produces a marked and progressive refinement of the graphite flakes in all of the sections which are grey.[6]

The investigation of the unetched surfaces of these same irons, Nos. 56*A*, 56*B*, 56*E* and 56*F* (T.C, 1.98; Si, 1.75; Mn, 0.52; Cu, 0.56 to 3.95 per cent.), reveals that all of them contain small particles of copper, usually euhedral crystals. These crystals are very small, about 0.001 mm., and frequently occur near a sulphide particle. The quantity of these copper crystals does not appear to be markedly affected by high copper contents since the copper present in these tiny crystals is about the same amount, probably not over 0.2 per cent. copper, in heat No. 56 through the range of copper content in this heat. Even after slow cooling from 750 deg. C., the quantity of the copper precipitated did not increase. It is quite probable that the occurrence of these small copper crystals is intimately connected with the sulphide. K. L. Meisner[7] found that, in the absence of manganese, the sulphur would be present as Cu_2S, but in the presence of manganese it would occur as MnS. If the sulphur occurs as Cu_2S, one part of sulphur would cause the formation of about twice as much sulphide as compared with manganese sulphide. It is quite possible that, when sulphur occurs with manganese, iron and copper in the proportion of copper-bearing iron, the sulphur is present as Cu_2S or as complex sulphide. This statement is based on the following observations:—(1) The light colour of the sulphide; (2) well-formed euhedral crystals instead of the rounded ones typical of MnS; (3) the large quantity of sulphide produced by a small sulphur content.

The copper produces a finer fracture than corresponding plain iron. This refinement of the fracture by the copper is most pronounced in the lower silicon irons, particularly when the low silicon is accompanied by low carbon content.

Permanent Growth and Resistance to Scaling

The dry-sand gates of heat No. 30 were machined to cylinders of ⅞-in. dia. and 3-in. long, producing six specimens for each of the five compositions of this heat. These specimens contained 3.15 per cent. total carbon and 1.5 per cent. silicon, while the copper contents were 0.20, 1.25, 2.3, 3.55 and 5.08 per cent. One set of these specimens was heated to 750 deg. C. for 1 hr. and furnace cooled. A second set was heated twice to 750 deg. C. and furnace cooled, a third set three times, etc., the sixth set being reheated six times. The increase in length and the increase in weight of each specimen were carefully determined, thus giving accurate data on permanent growth and scaling at 750 deg. C. in the fairly oxidising conditions existing in the closed muffle of the furnace. The data obtained clearly showed that, in this iron investigated, the copper had no effect upon the amount of scale found nor upon its adherence to the iron.

The following data show the increase in inches for the 0.2 per cent. and 3.55 per cent. copper specimens after the first, third and sixth heatings to 750 deg. C.:—

No. of heatings to 750 deg. C.	Increase in length. In.	
	0.2 per cent. Cu.	3.55 per cent. Cu.
1	0.0125	0.0165
3	0.0185	0.0225
6	0.0195	0.0260

These data are representative of the increase in permanent growth with increasing copper, the rate of this increase being the greatest up to 2 per cent. copper.

Data on permanent growth obtained by R. J. Marcotte[8] using a Leitz dilatometer also show that the iron of heat No. 27 (T.C, 3.15; Si, 2.50; Cu, 0.16 to 3.36 per cent.) has a greater permanent growth with increasing copper, after reheating 4 times to 875 deg. C., the increased growth being of the same order of magnitude as that represented by the previous data.

Coefficient of Thermal Expansion

Coefficients of thermal expansion, determined by R. J. Marcotte on heat No. 27, show that the coefficient of thermal expansion is not affected by the copper content up to about 500 deg. C., but that when this temperature is reached the coefficient increases slightly. The following data show the value of the coefficient of thermal expansion per 1 deg. C.

No.	Analysis. Per cent.			Coeff. of thermal expansion per deg. C. × 10^6.		
	T.C.	Si.	Cu.	25–200 deg. C.	25–400 deg. C.	25–600 deg. C.
27*A*	3.21	2.49	0.16	10.55	12.47	13.33
27*B*	3.16	2.55	0.83	10.67	12.9	13.64
27*C*	3.15	2.51	1.54	10.61	12.79	13.71
27*D*	3.16	2.51	2.46	10.39	12.90	13.98
27*E*	3.11	2.47	3.36	10.39	12.90	14.06

Thermal Critical Points

The temperatures of the thermal critical points, determined simultaneously with the coefficient of thermal expansion, show that the copper lowers both the $Ac_{2,1}$ and $Ar_{2,1}$ in the cast iron of heat No. 27. The $Ac_{2,1}$ is lowered uniformly 6 deg. C. for each per cent. copper up to at least 2.5 per cent.

4 Reed, E., Trans., A.S.S.T., Vol. 20, No. 2, pp. 115–175 (1932).

5 Smith, C. S., Trans. A.I.M.E., Vol. 116, pp. 363–385 (1935).

6 Photomicrographs available in manuscript, *loc. cit.*, Note 1.

7 Meisner, K. L., "Metal und Erz," Vol. 18, pp. 358–359 (1921).

8 Department of Physical Metallurgy, Michigan College of Mining and Technology.

The $Ar_{3\,2\,1}$ is lowered uniformly 13 deg. C. for each per cent. of copper up to at least 2.5 per cent. The heating rate through the critical temperature was about 12.5 deg. C. per min. and the cooling rate about 11 deg. C. per min.

Copper-Manganese Cast Iron

So far as the authors are aware the use of high manganese with copper (more than 0.8 per cent. manganese being considered high) has never received attention. The copper-manganese combination as alloying materials in grey iron offers the advantage of cheapness as compared with other alloying elements. This factor, together with the improved properties attained by the use of these metals as alloying materials, should stimulate their development in the grey iron industry.

An attempt was made to add the manganese in the cupola as a high-manganese pig, producing a base-iron containing 2.0 to 3.0 per cent. manganese to which the copper might be added. The straight high-manganese grey iron without copper has not been fully studied, and the effects of high manganese alone are rather obscure. However, the addition of high-manganese pig to the charge produced an iron containing 1.5 to 2.5 per cent. manganese which had a slight but definite tendency to form white iron in small sections, and to increase chill even if the silicon was maintained above 1.75 per cent. to permit machining. Such a grey iron, though the heat was repeated several times, was invariably unsound and weak and was little improved by the copper additions. However, this method has been used with success in chilled iron—which phase of the cast iron programme is not reported in this Paper. It is interesting to note that the effect of copper upon the decomposition of free cementite is about the same in this high-silicon, high-manganese iron as in the high-silicon iron of normal manganese content—*i.e.*, the copper retards graphitisation slightly.

After several unsuccessful attempts to add manganese in the cupola in the form of a high-manganese pig with a view to producing a high-manganese grey iron, a new method was tried. This consisted of melting copper and standard ferro-manganese together, forming a copper-manganese alloy which has a melting point much under that of pure copper. The alloy, formed by melting the copper and standard ferro-manganese (80 per cent. manganese) in a ratio of 5 to 3, was added molten to the forehearth or ladle in precisely the same manner as the molten copper was added to form the plain copper irons. Such a copper-manganese alloy would contain about 63 per cent. copper, 32 per cent. manganese, and 5 per cent. iron. No difficulty was experienced in producing a sound iron by this method of alloy addition. The alloy could be added solid in the form of shot when the cupola was tapped, because it melts readily and dissolves in the melt, forming a homogeneous alloy cast iron.

The same base-irons as were used for the plain copper grey iron were made, each being run in quadruplicate, two with the alloy additions increasing with the slightly decreasing casting temperature, and two with the alloy additions decreasing with the slightly decreasing casting temperature. The method of melting and testing the iron was the same as that described previously for the plain copper irons. The copper-manganese alloy was added molten, just as the copper was first melted before being added to the plain copper grey irons.

All of the six base-irons, excepting *C*, set out at the beginning of this Paper, have been run to date, each in quadruplicate, all unsatisfactory heats having been repeated. Thus 20 or more heats have been cast, each having 5 or 6 copper-manganese alloy additions with a corresponding number of sets of test bars. Beside these 126 different compositions of copper-manganese grey iron, six heats of a high-manganese base-iron were run, but they were unsound and were, therefore, not fully tested. They gave valuable information, however, regarding the effect of copper on the hardness and graphite formation in such high manganese iron.

Results of Testing Copper-Manganese Grey Iron

Theoretically, the copper and manganese should increase in the ratio of 2 to 1, since this is the ratio of copper to manganese in the alloy. However, there is a marked tendency for a preferential solution of the manganese in the alloy by the iron, leaving the copper-rich liquid at the bottom or to be dissolved later. It is thus possible to have varying proportions of copper and manganese. Because of this factor and the initial content of 0.5 to 0.7 per cent. manganese, the ratio of copper to manganese varies considerably, but it is nearly 1 to 1 when the alloys are present in amounts of from 1.5 to 3.0 per cent.

Representative data on the copper-manganese grey iron are graphically presented by plotting the relationship of a property to the copper plus manganese contents (Fig. 4). This is done with the realisation that the copper plus manganese content is two variables rather than one, particularly since the ratio of the two elements is not constant. The enormous amount of data required to utilise a method of representation involving three variables makes its use impracticable here. However, the uniformity of the curves obtained by the method employed in this Paper justifies its use for purposes of correlation.

Hardness

Examination of the data presented graphically in Fig. 4C shows that the copper-manganese addition increases the Brinell hardness very markedly, the increase being slightly greater for the green-sand bars. The increasing copper and manganese increase the Brinell 35 to 50 points at about 1.5 per cent. each of these alloying metals, the increase in hardness being about 5 points Brinell more for the green-sand bars than for the dry-sand bars of the same group. Further, the increase is about 5 points more for the higher silicon as compared with the lower silicon iron of the same total carbon content.

This relationship of increased hardness and the slight modification of this increase by the silicon content are further substantiated by similar data on groups *E* and *F* which were made with 60 per cent. steel in the charge. The data on these heats show that for similar silicon content, the lower carbon iron has a slightly lower increase in Brinell as compared with the corresponding higher-carbon groups *A* and *B*, this lower increase being about 5 points Brinell at about 1.5 per cent. each of copper and manganese.

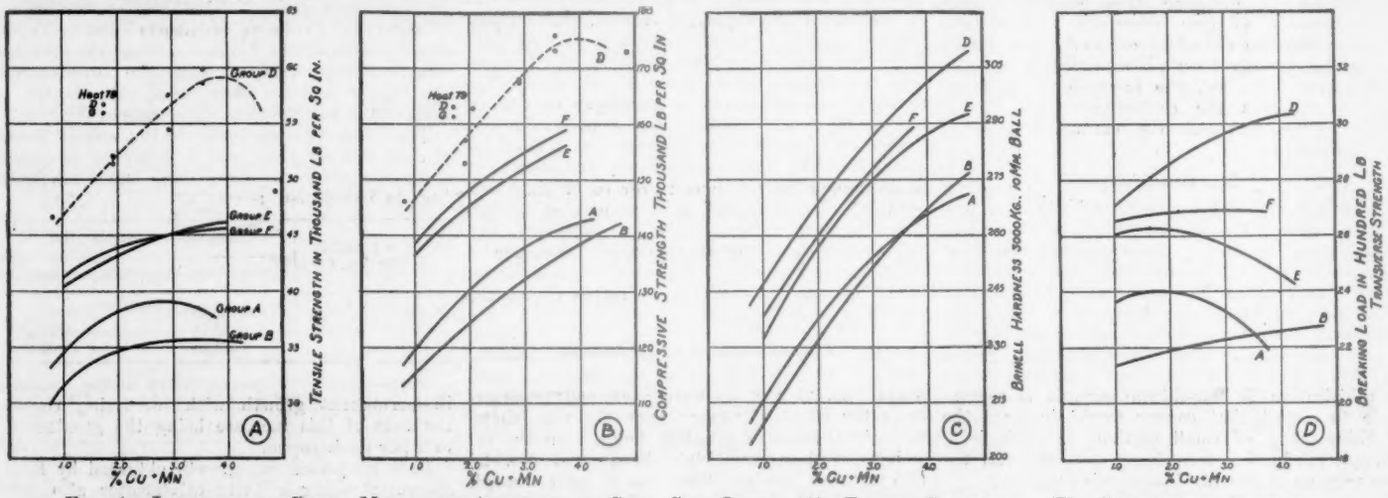


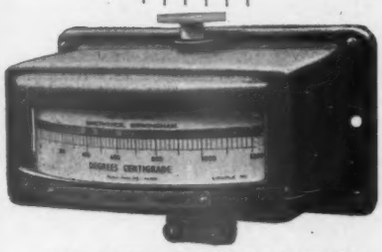
FIG. 4.—INFLUENCE OF COPPER-MANGANESE ADDITIONS TO GREY CAST IRON. (A)—TENSILE STRENGTH. (B)—COMPRESSIVE STRENGTH. (C)—BRINELL HARDNESS. (D)—TRANSVERSE STRENGTH.

The Brinell hardness of the 4-in. blocks, measured 1-in. from the centre of the section, also shows a marked increase in hardness with increasing copper and manganese content. At about 1.5 per cent. each of copper and manganese, the increase in Brinell is 45 points for groups *A* and *B* and 40 points for groups *E* and *F*, showing that the silicon has very little influence upon the increase and that the lower carbon manifests itself in the slightly lower increased hardness.

The increased hardness with increasing copper and manganese content is further substantiated by the hardness of the various sections of the step bars. The increase in hardness from the centre to the exterior of the 4-in. blocks is not affected by the alloy addition; hence, the uniformity of hardness within a section from interior to exterior is not materially affected.

The difference in hardness of the 4-in. sections (measured 1-in. from the centre) and the ¼-in. sections increases with alloying content, showing that the copper-manganese hardens the iron more in small sections. This increased hardness in the small sections, amounting to 20 points Brinell in the high carbon groups *A* and *B* and 35 points Brinell in the lower-carbon groups *E* and *F* at 1.5 per cent. each of copper and manganese, is not to be accounted for by the assumption of retardation in graphitisation, since this increase in hardness can be accounted for readily, as it can be in the case of plain copper grey iron also, by the critical degree of dispersion of the alloying material in the more rapidly cooled small

(*Concluded on page 240.*)



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sections and by the tendency of the alloying element to render the more rapidly cooled sections sorbitic. The latter is, of course, most pronounced in small sections and in the iron alloyed with a copper-manganese addition.

Tensile Strength

The data show that when copper and manganese are present to the extent of about 1.5 per cent. each, both the dry-sand and green-sand bars of both high and low silicon contents are increased in tensile strength, this increase frequently being over three tons per sq. in. Here again the copper-manganese addition is as effective in high-silicon iron as in low-silicon grey iron. The relationship of copper plus manganese contents to the tensile strengths of the green- and dry-sand bars of groups *A*, *B*, *E*, and *F* is illustrated by Fig. 4A.—The data for heat 79 (T.C, 2.87; Si, 2.06; Mn, 1.00; Cu, 0.1 to 3.28 per cent.) are plotted as representative of group *D*, since this is the only heat in this group that has been tested to date.

Compressive Strength

Enormous increases in compressive strength occur in both the dry-sand and green-sand bars of both high and low-silicon contents. With copper and manganese of moderate value, 1.5 per cent. each, the increase is 8.9 and 13.3 tons per sq. in.; in heat No. 48 which is very high in silicon (3.0 per cent.), the increase at approximately 2.5 per cent. each of manganese and copper is 19.2 tons per sq. in. as compared with the plain base-iron. The relationship of the copper plus manganese contents to the compressive strengths of the green- and dry-sand bars of groups *A*, *B*, *E* and *F* is shown in Fig. 4B. Here again the data for heat 79 are plotted as representative of group *D*.

Transverse Properties

The data derived show that the breaking load of the green- and dry-sand bars is generally increased slightly, the increase being 100 to 200 lb. at about 2.5 per cent. of copper plus manganese for the 1.2-in. diameter bars broken on an 18-in. span. In iron with a higher alloy content than that just noted, there is generally no further improvement in transverse strength. These effects of the copper-manganese additions upon the transverse properties are further substantiated by the transverse properties of groups *E* and *F*. The low-carbon, low-silicon group *E* is not improved beyond 2 per cent. of copper plus manganese (Fig. 4D).

The increased hardness produced by fairly high percentages of copper and manganese is reflected in lower deflections but, unlike the plain copper iron, a slight improvement in deflection is produced by the first additions of the copper-manganese alloy.

Total Shrinkage.—Like copper alone, the copper-manganese increases total shrinkage progressively with greater alloy addition, this increase being about the same for all groups *A*, *B*, *E*, and *F* and amounting to 0.02 in. per ft. at about 1.5 per cent. each of copper and manganese.

Influence of Copper-Manganese on Chill

When the copper-manganese alloy is added in the ratio used in these tests, it is found that the chill on the chill block decreases from $\frac{1}{16}$ to $\frac{1}{4}$ in. at about 1.5 per cent. each of copper and manganese in the high-carbon, low-silicon group *A*. There is a corresponding slight decrease in the chill in low-carbon, low-silicon group *E*. However, the decrease in chill is less than that observed in group *A*. The copper-manganese additions neither increase nor decrease the amount of chill in the high-silicon groups *B* and *F*, even when the sum of copper plus manganese exceeds 4.0 per cent. It is, then, evident that the copper-manganese alloy influences chill much as copper alone does and that its effect is likewise influenced by the silicon content.

Chill in Small Sections

The effect of the copper-manganese upon the chill in small sections is closely related to its effect upon the amount of chill on the chill blocks, since in both instances the white iron is due to rapid cooling. The influence of copper-manganese upon the amount of chill in small sections was investigated by the step-bar cast in green sand, described previously. The copper-manganese alloy used in these tests had no influence upon chill of small sections in groups *B*, *E*, and *F* set out in the beginning of the Paper, but when the silicon is lower and the total carbon higher, as in group *A*, the copper-manganese alloy decreases chill slightly. This decrease is about 1-in. as measured from the small end of the step-bar. Thus, the plain iron, 53*E* (T.C, 3.25; Si, 1.38; Mn, 0.62; Cu, 0.16 per cent.), had a 1.5-in. chill measured from the tip of the small end of the step-bar, while 53*A* (T.C, 3.32; Si, 1.41; Mn, 1.28, and Cu, 1.49 per cent.) containing 1.4 per cent. copper and 1.4 per cent. manganese, had a ½-in. chill. These figures are typical for this group.

Red Shortness.—The possibility of red shortness in the copper-manganese grey irons was investigated in the same manner as that employed for the plain copper iron. The results of the tests definitely prove that the alloy cast iron has no greater tendency to be red short than the plain cast iron.

Microstructure and Fracture

The copper-manganese additions cause a progressive refinement of the graphite. Also, microscopic study reveals the tendency of the pearlitic structure of No. 47*A* (T.C, 3.32; Si, 2.35, Mn, 0.69; Cu, 0.19 per cent.) and similar heats, to be replaced by a fine sorbitic structure with increasing alloy addition. The fractures of the various sized sections are always finer with increasing copper-manganese additions.

Future Research

It is intended that future research on the effects of copper in cast iron will include:—(1) Complete testing of the remaining copper-manganese irons not reported in this Paper; (2) the study of copper with chromium in grey iron; (3) the study of copper with nickel in grey iron; (4) the investigation of copper-manganese austenitic cast iron; (5) the investigation of copper or copper with other alloying materials in white cast iron; and, possibly (6), the study of malleable iron with plain copper or copper in conjunction with other alloying materials.

Some work on the austenitic copper-manganese cast iron has already been done, with encouraging results, but because of pressure on the time available for the project, this phase of the work has been temporarily discontinued. The investigation into the use of copper in white and chilled iron is in progress, and a report will follow this Paper in a short time.

Acknowledgments

The work reported in this Paper was carried on as a part of the research programme of the Michigan College of Mining and Technology with aid provided by the Federal Emergency Relief Administration. Sincere appreciation is expressed for the interest of Mr. L. M. Nimms, F.E.R.A. director, works division of the Michigan Emergency Relief Administration, and for the aid and encouragement of Prof. A. T. Sweet, head, Department of Metallurgy, Michigan College of Mining and Technology. The authors also express their sincere appreciation to the Cleveland-Cliffs Iron Mining Company, which, under the direction of E. T. Olson, performed a considerable portion of the analytical work and otherwise aided the project. The advice and co-operation received from Mr. R. S. MacPherran, chief metallurgist, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., and from Mr. Ed. Nelson, foundry superintendent, Calumet & Hecla Consolidated Copper Company, has been invaluable. Messrs. Garrett, Leisk, Fleming, Maynard, Davis, Nikkila, Bidigare, Barkell, Orem and Shea had active parts in this work, and their services are also gratefully acknowledged.

United States Production of Pig-Iron and Ferro-Alloys

JANUARY TO JUNE, 1936

Statistical Bulletin No. 4 of the American Iron and Steel Institute reports on the production of pig-iron and ferro-alloys in the United States in the first six months of the current year. The tables issued show that pig-iron production was 13,367,785 gross tons in that period as compared with 11,070,861 tons in the second half of 1935 and 9,709,899 tons in the first half of that year.

The principal producing States in January to June last (and July to December, 1935, in parentheses) were:—Pennsylvania, 3,752,592 (2,997,640) tons; Ohio, 3,227,197 (2,896,430) tons; Indiana and Michigan, 1,890,895 (1,595,336) tons; Illinois, 1,350,995 (1,065,250) tons; and Alabama 995,852 (649,555) tons. The total output of pig-iron included 9,067,681 (7,148,231) tons of basic iron, 2,448,248 (2,159,867) tons of Bessemer and low-phosphorus iron, 966,369 (1,037,066) tons of foundry iron, and 829,025 (666,675) tons of malleable pig-iron.

The production of ferro-alloys in blast furnaces and electric furnaces totalled 384,347 tons in January to June last, compared with 334,149 tons in July to December, 1935, and 257,790 tons in January to June, 1935. The ferro-alloy output included 177,284 tons of ferro-manganese and spiegeleisen and 178,847 tons of ferro-silicon.

Of 236 blast furnaces built on June 30, 1936, 135 were in blast on that date making pig-iron, as against 115 on December 31 last. Of these, 41 (30) were in use in Pennsylvania, 30 (27) in Ohio, 13 (10) in Illinois and 12 (10) in Indiana. There were 17 blast furnaces for making ferro-alloys in existence on June 30 last, of which 11 were in blast, as against 9 on December 31, 1935.

Catalogue Received

Asbestos. The Asbestos Manufacturers, Limited, of 47, Victoria Street, Westminster, London, S.W.1, have sent us a well-printed and splendidly illustrated catalogue dealing with a great diversity of articles made from asbestos. A convenient system of thumb notching enabled us to turn immediately to asbestos clothing. In this section are shown gloves, hoods, capes and leggings, whilst other chapters deal with belting, hose pipes, packings and asbestos in the form of cloth, yarn and millboard. To our mind a psychological error has been made by the inclusion of a leaflet headed "Non-combine," because in general if a non-combine establishment ever does join the "association" it is rare for buyers to show their appreciation of past services.

Stainless and Heat-Resisting Iron-Chromium Cast Alloys

(*Concluded from page* 233.)

ment it is possible to impart a high wear-resistance to the alloys with a Brinell hardness number between 400 and 500. In this case machining can be carried out only with the aid of Widia tools.

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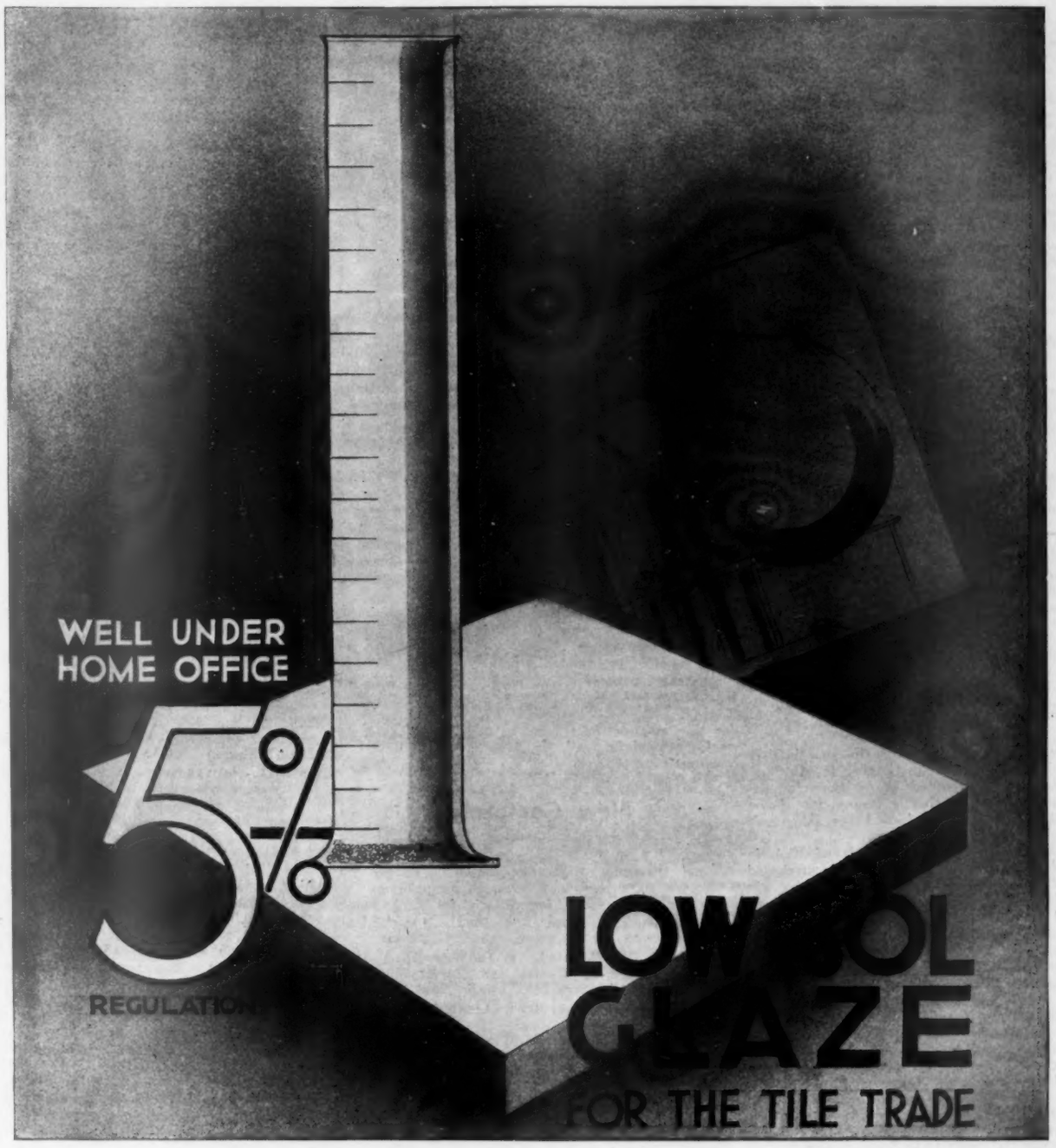

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The Week's News in Brief

Trade Talk

THE OFFICES of the Import Duties Advisory Committee will on and after September 22 be at Shell-Mex House, Strand, London, W.C.2.

THE BRITISH ALUMINIUM COMPANY, LIMITED, have secured a 25 per cent. reduction in the recently-assessed value of their Kinlochleven works.

THE BELFAST HARBOUR BOARD have accepted the tender of the Clyde Crane & Engineering Company, Limited, for two 5-ton electric grab cranes.

THE PHOSPHOR BRONZE COMPANY, LIMITED, have changed their London office to 54, St. Thomas's Street, Borough, London, S.E.1. Their new telephone numbers are Hop 0703 to 0705.

STEWARTS AND LLOYDS (AUSTRALIA) PTY., LIMITED, is extending its steel pipe and tube works at Newcastle, N.S.W., according to Australian advices. It is estimated that almost £500,000 will be spent on the work.

AN IMPORTANT EXTENSION of the British Industries Fair buildings in Birmingham was decided upon by the Fair Management Committee on Monday. The total indoor exhibiting space will exceed 300,000 sq. ft. when that extension is completed.

THE ORDER for the light-section mill which is to be installed at the works of the Skinningrove Iron Company, Limited, was placed with the Brightside Foundry & Engineering Company, Limited, Sheffield, and is now in course of manufacture.

LOBNITZ & COMPANY, LIMITED, Renfrew, are to construct three salvage tugs for the South African Railways Harbour Administration. The vessels will be fitted with 2,600-h.p. engines, and will be amongst the most powerful of their type in the world.

THE BELGIAN FOUNDRY TECHNICAL ASSOCIATION will commemorate its twenty-fifth anniversary at a meeting to be held in Liége on Sunday, September 25, when Prof. A. Portevin will present a Paper on "The Metallurgical Evolution of the Foundry."

APPROXIMATELY 98 PER CENT. of the shareholders of the Birmingham Aluminium Casting (1903) Company, Limited, have accepted the scheme for exchanging their shares in that company for shares in Birmid Industries, Limited, and the scheme is therefore being proceeded with.

J. BROCKHOUSE & COMPANY, LIMITED, of Victoria Works, Hill Top, West Bromwich, have purchased six acres of land, with an option on a further six acres, in Livingstone Street, Clydebank. The company intend to erect a factory for the manufacture of motor parts and trailers.

THE KING saw the first pillar-box bearing the monogram of King Edward VIII on his visit to Balmoral Castle. The new Royal monogram will appear on about 3,000 new posting-boxes of all kinds, which will be provided in various parts of the United Kingdom during the next 12 months.

THE APPOINTMENT of Mr. Douglas A. Duncan, of Cardiff, as general manager of the South Wales and Monmouthshire Trading Estates, Limited, is announced. The company was formed under the Special Areas (Development and Improvement) Act, 1934, to acquire and develop suitable sites for industrial and commercial projects in South Wales.

AN EXAMINATION for admission to associate membership of the Institute of Marine Engineers is to be held from November 16 to 19. The annual examination for admission of probationer students and students will be held in June, 1937. Full particulars of the syllabus and exemptions allowable may be obtained on application to the secretary, the Institute of Marine Engineers, The Minories, London, E.C.3.

THE FIRST LARGE contract since the works reopened in April this year is just being completed by the Darlington Forge, Limited. The contract is for the supply of castings for four vessels being built at Barrow-in-Furness. The castings—shaft brackets, stern frames and rudder castings—constitute the largest single comprehensive order received by the recently reorganised firm, though many other similar orders have been executed since the reopening. The hope that the works would before long be functioning to normal capacity is almost realised. Approximately 750 hands are working.

THE NATIONAL EXECUTIVE COMMITTEE of the United Patternmakers' Association has decided to make representations to the employers for a revision of the present national agreement governing wages and conditions in the industry. The principal proposals to be put forward by the association are a request for 1s. 9d. per hour, which represents an increase of from 2d. to 3d. per hour on the present rates; an extra wage allowance for operating patternmaking machines, and the abolition of a number of anomalies in the existing national agreement. Between 10,000 and 12,000 workers throughout the country are affected by the proposals.

Company Reports

Radiation, Limited.—Interim dividend on the ordinary shares of 3¼ per cent.

British Insulated Cables, Limited.—Interim dividend of 5 per cent. on the ordinary stock.

A. Reyrolle & Company, Limited.—Interim dividend of 5 per cent. on the ordinary shares.

Coltness Iron Company, Limited. — Interim dividend on the ordinary shares of 9d. per share or 5 per cent.

Worthington-Simpson, Limited.—Interim dividend of 3 per cent. in respect of the half-year ended June 30 last on the 6 per cent. cumulative preference shares.

Horseley Bridge & Thomas Piggott, Limited.—Profit, after charging debenture interest, depreciation, etc., £24,798; brought in, £231; carried forward, £25,028.

United Steel Companies, Limited.—Final dividend on the 6,616,365 shares of £1 fully paid and converted into stock of 5 per cent., making 7½ per cent. for the year ended June 30.

Qualcast, Limited.—Net profit, £49,817; brought in, £47,778; staff bonus, £5,758; income tax, £10,221; final dividend of 10 per cent., making 15 per cent. for the year, together with a cash bonus of 5 per cent.; carried forward, £56,914.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Textile Accessories, Limited, District Bank Buildings, Macclesfield.—Capital, £1,000. Ironfounders, etc. Directors: H. Harrison and S. G. Bown.

Bailey & Gill, Limited, 76, Oakham Road, Harborne, Birmingham.—Capital, £2,000. Machine tool makers, etc. Directors: S. O. Bailey and E. Gill.

Thomas Jennings & Sons, Limited, Permanent House, The Headrow, Leeds, 1.—Capital, £1,000. Ironfounders, manufacturers of machinery and implements, etc.

Hodgkins Bros., Limited, 40-44, Wainwright Street, Birmingham.—Capital, £4,000. Engineers and machine tool makers. Directors: E. J. Hodgkins and Miss G. A. Hodgkins.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

451,272. BOECKER, G. Process of producing hard metal alloys.

451,463. MALSCHAERT, R. Process for making iron-silicon alloys.

451,472. SOC. ANON. DES HAUTS-FOURNEAUX DE LA CHIERS. Protection of cast iron and steel against oxidation at high temperature.

451,499. UNITED STEEL COMPANIES, LIMITED, and MASON, B. G. Metal railway chairs and sleepers.

Personal

MR. JOHN A. BROWN and Mr. George Muirie have been appointed directors of Allied Ironfounders, Limited.

MR. G. T. LUNT informs us that on and after September 28 his private address will be San Simeon, Newbridge Crescent, Wolverhampton.

MR. WILLIAM ROYCE LYSAGHT, chairman of John Lysaght, Limited, was recently admitted a Freeman of Newport, Monmouthshire. Mr. Lysaght's workmen, by whom he is held in high esteem, have erected an institute to perpetuate his name. A strike is unknown in the history of the firm.

ON THE OCCASION of his leaving the Parkinson Stove Company, Limited, Birmingham, to take up the position of foundry manager with the Vulcan Stove Company, Limited, Exeter, Mr. E. James, of the foundry moulding department, was presented with a gold wristlet watch by the works staff. The presentation was made by the works manager, Mr. W. Todd. Mr. James also received a presentation from the employees in the moulding department.

Wills

MARSHALL, MAJOR H. D., of Gainsborough, engineer, late chairman and managing director of Marshall, Sons & Company, Limited £128,301

AITKEN, ARCHIBALD, managing director, Burton Foundry Company, Limited, the Welwyn Foundry Company, Limited, and director of Allied Ironfounders, Limited £59,243

Obituary

MR. HARRY ALFRED RICHARDSON, a director of Hick, Hargreaves & Company, Limited, Soho Ironworks, Bolton, has died in his 80th year.

MR. GEORGE J. WOOD, London agent of the Clay Cross Company, Limited, since 1909, died on Sunday, September 13, at the age of 56 years.

THE DEATH HAS OCCURRED of Mr. Robert Marshall, J.P., a director of Hill & Smith, Limited, structural engineers and founders, of Brierley Hill, Staffordshire.

MR. E. SOMERS-SMITH, whose death occurred last week, was secretary of Walter Somers & Company, Limited, of Haywood Forge, Halesowen. He was 42 years of age.

MR. W. C. M. JAMES, iron and steel merchant, of Exchange Buildings, Stephenson Place, Birmingham, died last week. Mr. James was one of the oldest members of the Birmingham Iron Exchange.

MR. PHILIP REES HOPKINS, J.P., who retired three years ago from the post of general manager of the Malleable (Stockton) Works of the South Durham Steel & Iron Company, Limited, died last week at his residence in Stockton, in his 74th year.

MR. JAMES ALLEN GOODWYN, a director of Ransomes, Sims & Jefferies, Limited, and of Ruston & Hornsby, Limited, has died suddenly, at the age of 59. Mr. Goodwyn entered Ransomes' agricultural and general engineering works as an apprentice in 1895. He joined the board in 1917, and was controller of export sales at his death. He was elected a director of Ruston & Hornsby, Limited, when the companies became associated in 1919.

Contracts Open

Hertford, October 6.—5,900 yds. of 12-in. and 6-in. cast-iron mains, for the Town Council. D. Balfour & Sons, 47, Victoria Street, Westminster, S.W.1. (Fee £5, returnable.)

Kearby-with-Netherby, September 29.—5,600 yds. of 3-in. spun-iron pipes and 500 yds. 1-in. wrought-iron pipes, for the Wetherby Rural District Council. F. J. Rodwell & Son, consulting engineers, 20, Park Row, Leeds. (Fee £2 2s., returnable.)

Kidderminster, October 6.—3,950 yds. of 3-in. cast-iron pipe water main, for the Rural District Council. Fiddian & Deeley, engineers, 13, Church Street, Stourbridge. (Fee £3 3s., returnable.)

Forthcoming Events

SEPTEMBER 16-27.
International Foundry Exhibition in Düsseldorf.

SEPTEMBER 21-26.
Iron and Steel Institute:—Autumn Meeting in Düsseldorf.

THE "ROCKET" CORE MAKING MACHINES

HELP to . . .

REDUCE COSTS AND MAKE SOUND CASTINGS

for

BRITISH

— STEEL FOUNDERS —
GREY IRON FOUNDERS
MALLEABLE FOUNDERS
NON-FERROUS FOUNDERS

used in the manufacture of—

Electric Cookers. Gas Cookers. Motor Transport Vehicles. Aeroplanes. Internal Combustion Engines. Cast Iron Bath Fittings. Brass Water Service Fittings. Sluice Valves. Gas Valves. Rain Water Castings. Textile Machinery. Lawn Mowers. Ship Building, etc., and General Engineering Castings.

FOUNDRY ENGINEERS LIMITED

HALIFAX —— YORKS.

Telephone: Halifax 61459. Telegrams: "FEL," Halifax.

Raw Material Markets

Autumn prospects for the iron and steel industry are very satisfactory. Consumers have exceptionally heavy requirements, and makers are pressed for deliveries against existing contracts. Outputs are at very high levels. At a meeting of the heavy steelmakers in London last week no change in quotations was effected.

Pig-Iron

MIDDLESBROUGH.—Much talk of a shortage of pig-iron is heard in this area, but, while this is a possibility for the future, producers are still able to supply sufficient material to cover immediate requirements. Supplies for stocking purposes are not to be had, and export business is confined to very meagre tonnages. The fact that makers are willing to book contracts for delivery up to the end of March at present prices indicates that quotations are not likely to be altered before that period has expired. For delivery in the Middlesbrough and Falkirk areas No. 3 Cleveland G.M.B. iron is quoted at 75s. per ton.

Considerable tonnages of basic and hematite have been sold for delivery up to the end of February, 1937. Most consumers are anxious to cover their needs over as long a period as possible owing to the probability of higher values being created as costs of production are increasing. Current prices for East Coast mixed numbers are 85s. per ton, less 5s. rebate, for delivery on the North-East Coast.

LANCASHIRE.—There has been a further improvement in pig-iron buying during the past week. Most consumers have fairly substantial stocks, but inquiries have involved some large tonnages. Makers of textile machinery have only moderate requirements, but satisfactory business has been transacted with the jobbing foundries, the machine-tool trade, the heavy electrical concerns, light-castings foundries and the special and general engineering establishments. Offers of Staffordshire and Derbyshire No. 3 foundry iron are at 83s. per ton, for delivery in the Lancashire price zone, with Northants at 81s. 6d., and Derbyshire forge iron at from 78s. to 80s., according to the class of consumer. There continues to be a good demand for hematite at unchanged prices.

MIDLANDS.—Active conditions continue to rule in the pig-iron market in this area. Makers are well sold and are not over anxious to further their commitments, which extend up to the end of March. Prices remain unchanged and, for delivery at Birmingham and Black Country stations, Northants No. 3 is quoted at 77s. 6d., and Derbyshire, Lincolnshire and North Staffordshire No. 3 at 80s. per ton. A small sliding-scale rebate is granted to large users. General engineers and jobbing founders have very satisfactory requirements of special irons, and the demand is steadily increasing. Prices are as follow :—Medium-phosphorus iron, 82s. 6d., minimum, to 90s.; low-phosphorus, including Scottish, 92s. 6d. to 100s.; refined iron, £6 10s. to £8 10s., according to analysis and transport costs, etc. Forge iron is still quoted at 5s. per ton below ordinary No. 3 foundry, but only 3s. less when required for foundry use. There is a good demand for this grade, and supplies are sometimes difficult to obtain. Business in hematite has been transacted up to the end of February, but makers are well sold and there are only small tonnages for sale from the West Coast, while East Coast iron is a little easier to procure. East Coast No. 3 is quoted at £4 16s., West Coast mixed numbers at £4 17s., and Welsh mixed numbers at £4 15s. 6d., delivered local stations. For delivery into works 1s. 6d. per ton extra is charged.

SCOTLAND.—The light-castings founders in this area continue to be very well employed, and their pig-iron requirements are substantial. Prices are unaltered, with No. 1 grade at 81s. 6d. and No. 3 foundry at 79s. per ton, f.o.t. furnaces. Further imports of basic iron have been made during the past week from Russia and India, about 12,000 tons arriving from the former country. Quotations for No. 3 Cleveland are 75s. f.o.t. Falkirk and 78s. f.o.t. Glasgow. The steelworks continue to be very actively employed, and they are having difficulty in obtaining their full needs. Prices remain unchanged, mixed numbers of East Coast, West Coast and Scottish hematite being at 85s., less 5s.; with basic, British and Indian at 75s., less 5s. rebate, all delivered local steelworks.

Coke

Prices of foundry coke are almost certain to be raised, although the majority of users are covered for their winter requirements at current figures. The demand is still heavy. Present values are firm, and, for delivery in the Birmingham district, are 40s. to 42s. 6d. for best Durham foundry coke, with Welsh coke at from 40s. to 50s., according to quality.

Steel

No relaxation is apparent in the demand for steel materials, and the full output of most descriptions is passing into immediate consumption, says the official report of the London Iron and Steel Exchange. Specifications continue to reach the works on a heavy scale, and production resources are being severely taxed. In the semi-finished steel department suppliers are finding it difficult to meet the full requirements of the market and are doing their utmost to comply with repeated requests from consumers to accelerate deliveries. The demand from users of finished steel appears to be broadening as the autumn advances. Large tonnages are passing to the shipyards and to constructional engineering establishments, while great activity also prevails in the lighter branches of the industry, where most departments are in full operation. Lately a fair amount of export business has been transacted, but most of the manufacturers are concentrating upon meeting the insistent home trade demand.

Scrap

The demand for scrap from local steelworks has increased in the Cleveland area and buying is on a good scale. Heavy steel scrap is still at a minimum of 57s. 6d. per ton. Machinery cast-iron scrap is also in better request at 67s. 6d., while foundry cast iron has received more inquiries at 65s. The South Wales market is quiet owing to the shortage of supplies. The demand for heavy steel scrap is good at 64s., but trade is restricted, while good, clean, heavy, mild-steel turnings are quiet at 50s. to 53s. There is an improved demand for mixed wrought-iron and steel scrap for basic furnaces, but, owing to the high price of heavy material, little business has been transacted. Heavy cast-iron scrap, in large pieces and furnace sizes, is in moderate request at 58s. to 60s. Good cast-iron machinery in cupola sizes is quiet at 62s. to 64s. per ton. The Midland market is active, and all qualities of scrap receive a good demand. Heavy steel is at 51s. to 52s. 6d., with mixed iron and steel at 51s. Heavy unsheared wrought iron is at 65s., while machinery metal in cupola sizes is at 70s. Short, heavy steel, as used in the foundries, is at 65s. per ton, delivered works. Firm prices rule on the Scottish market, where a good demand is experienced. Heavy steel scrap is at 57s. 6d., and heavy basic, or heavy iron and steel mixed, in furnace sizes, is 5s. less. Heavy machinery cast-iron scrap is at 68s. 6d. to 69s. 6d. for pieces not exceeding 1 cwt., and ordinary cast-iron scrap, to the same specification, is 64s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—There has been a slight falling away in buying during the past week, but this was to be expected in view of the heavy purchases that have been made recently. Industrial demand is on a good scale, while rearmament plans involve the use of large tonnages of copper. On the Continent, buying on industrial account is satisfactory, but the Spanish civil war, together with the "stay-in" strikes in the French factories, have tended to restrict business somewhat. There have been no further developments in the United States price dispute, the Kennecott Corporation still retaining the view that it would be more favourable to the industry if quotations were not raised. However, a level of 10 cents per lb. for domestic copper in the United States is by no means unlikely. Meanwhile, buying has improved slightly.

The copper statistics for August were quite satisfactory. World stocks of refined metal decreased by 26,746 short tons. Apparent consumption was at 155,376 tons, as against 146,042 tons in the previous month.

Daily market prices :—

Cash.—Thursday, £38 16s. 3d. to £38 17s. 6d.; Friday, £38 18s. 9d. to £39; Monday, £39 2s. 6d. to £39 5s.; Tuesday, £38 18s. 9d. to £39; Wednesday, £38 15s. to £38 16s. 3d.

Three Months.—Thursday, £39 1s. 3d. to £39 2s. 6d.; Friday, £39 3s. 9d. to £39 5s.; Monday, £39 7s. 6d. to £39 8s. 9d.; Tuesday, £39 3s. 9d. to £39 5s.; Wednesday, £39 to £39 1s. 3d.

Tin.—There has been no official statement issued concerning the negotiations between Mr. Van den Broek and the Siamese Government. It is believed in Amsterdam that the result will be a compromise, making it possible for Siam to co-operate in the restriction scheme on a quota basis without seriously prejudicing the position of the other producing countries. The price of tin again rose near to the £200 mark, but fell sharply in mid-week. Buying interest has been maintained on a good scale, both in this country and in the United States. On the Continent, business has been quiet.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £194 10s. to £195 10s.; Friday, £198 5s. to £198 10s.; Monday, £198 to £198 10s., Tuesday, £195 5s. to £195 10s.; Wednesday, £192 5s. to £192 15s.

Three Months.—Thursday, £192 15s. to £193; Friday, £196 2s. 6d. to £196 5s.; Monday, £195 7s. 6d. to £195 12s. 6d.; Tuesday, £193 5s. to £193 10s.; Wednesday, £190 15s. to £191 5s.

Spelter.—No official information is available concerning the re-establishment of the Zinc Cartel, and the market continues to be disturbed by complicating rumours. One day the market is strengthened by reports of a "distinct possibility" of a conference of all interested parties, while the next day it is stated that there is no likelihood of any such event. Meanwhile, demand is steady. Smelter output in July was, according to the Metallgesellschaft, 125,744 metric tons, as compared with 121,754 tons in June.

Official quotations were as follow :—

Ordinary.—Thursday, £14 6s. 3d.; Friday, £14 1s. 3d.; Monday, £14 1s. 3d.; Tuesday, £14 1s. 3d.; Wednesday, £13 17s. 6d.

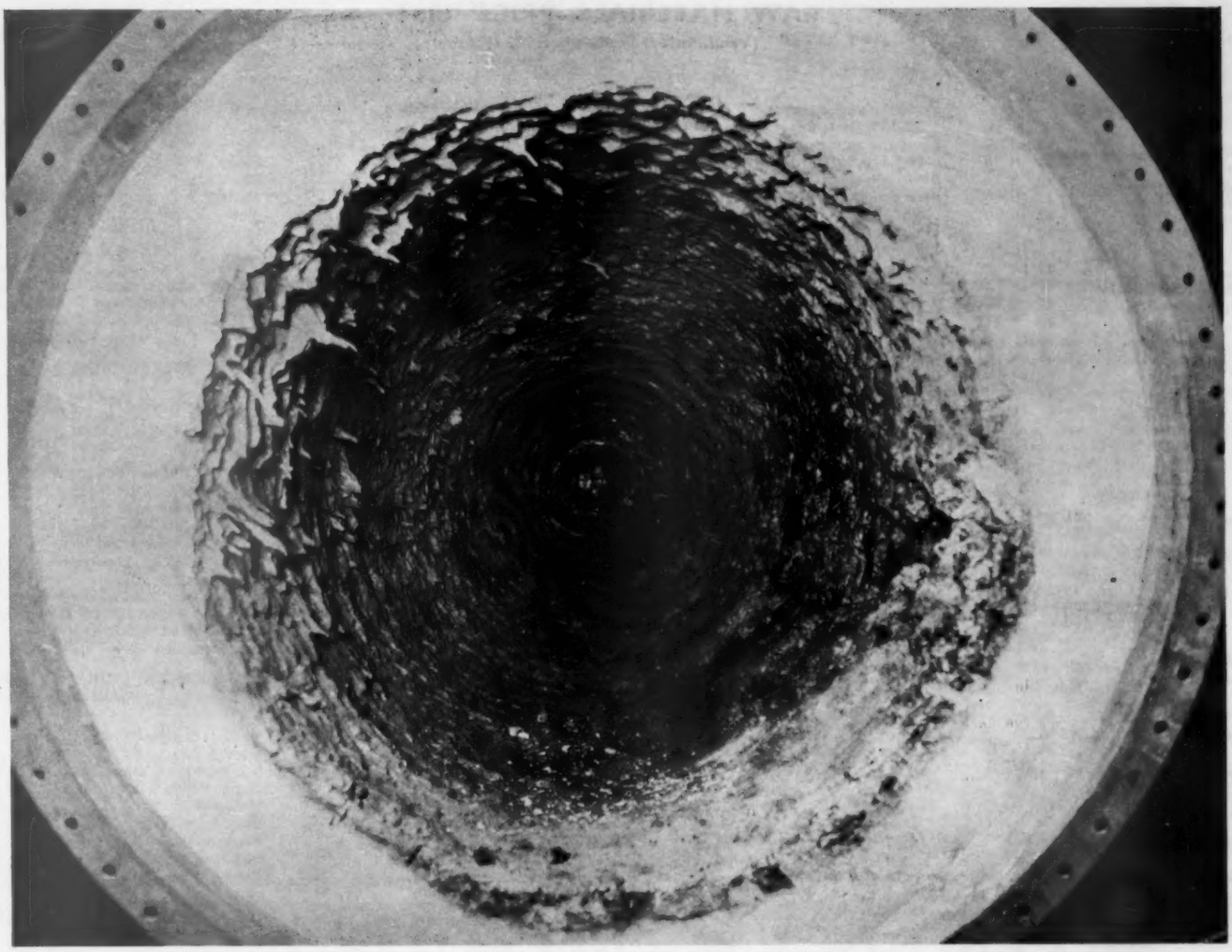
Lead.—Demand has been maintained on a good scale, and the market is very firm. It is sometimes difficult to procure supplies for near delivery. Prospects for the metal are excellent.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £18 8s. 9d.; Friday, £18 7s. 6d.; Monday, £18 7s. 6d.; Tuesday, £18 3s. 9d.; Wednesday, £18.

Catalogue Received

Electric Vibrating Screens. The considerable progress registered in recent years in the design and construction of Hum-mer screens is well recorded in a new catalogue recently issued by International Combustion, Limited, of Aldwych House, Aldwych, London, W.C.2. The system is lucidly explained and a number of photographs and drawings are included to illustrate both basic principles and normal applications. Whilst looking over this catalogue, our mind reverted to an application which we believe to be unexplored and novel. We suggest that for grit mixtures, the raw materials arrive at a height and are charged into the various bins provided with suitable dust extraction equipment. The floor of the bin would be a vibratable screen situated, say, two or three feet from the ground. A container placed on a pan of a weighing machine would, after raising a shutter, be wheeled under the screen, and the current started up and stopped as soon as the correct weight was delivered. The weight of material carried on the screen could be roughly regulated by a shelving placed above the screen. The Hum-mer has already been described in our columns in connection with a description of the company's foundry at Derby, but this catalogue well serves the purpose of extending that and other descriptions by indicating the large number of types available. The catalogue runs to twenty pages and is available to our readers on request.



950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles.
This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

ALBINO

ROTARY FURNACE LINING MATERIAL

Please write for further particulars to the sole manufacturers:

GENERAL REFRACTORIES LIMITED,

Genefax House, Sheffield, 10

Telephone: Sheffield 31113 (6 lines) Telegrams: "Genefax, Sheffield"

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

RAW MATERIALS—PRICE LIST

(Wednesday, September 23, 1936)

COPPER

	£	s.	d.
Standard cash	38	15	0
Three months	39	0	0
Electrolytic	43	2	6
Tough	42	0	0
Best selected	42	10	0
Sheets	72	0	0
India	53	0	0
Wire bars	43	15	0
Ingot bars	43	15	0
H.C. wire rods	47	5	0
Off. av. cash, Aug.	38	5	11½
Do., 3 mths., Aug.	38	11	3⅜
Do., Sttlmnt., Aug.	38	5	9
Do., Electro, Aug.	42	13	0
Do., B.S., Aug.	42	5	0
Do., wire bars, Aug.	42	18	6
Solid drawn tubes			11d.
Brazed tubes			11d.
Wire			6½d.

BRASS

Solid drawn tubes	10d.
Brazed tubes	12d.
Rods, drawn	9d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8½d.
Wire	8d.
Rolled metal	7⅝d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN

	£	s.	d.
Standard cash	192	5	0
Three months	190	15	0
English	192	10	0
Bars	194	5	0
Straits	194	5	0
Australian	192	5	0
Eastern	193	15	0
Banca (nom.)	194	5	0
Off. av. cash, Aug.	183	17	7½
Do., 3 mths., Aug.	180	17	1½
Do., Sttlmt., Aug.	183	17	0

SPELTER

	£	s.	d.
Ordinary	13	17	6
Remelted	13	15	0
Hard	12	0	0
Electro 99.9	15	17	6
English	15	0	0
India	13	0	0
Zinc dust	19	15	0
Zinc ashes	4	10	0
Off. aver., Aug.	13	12	10½
Aver. spot, Aug.	13	10	6¼

LEAD

	£	s.	d.
Soft foreign ppt.	18	0	0
Empire	18	18	9
English	20	0	0
Off. average, Aug.	16	16	3¾
Average spot, Aug.	16	15	5¼

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	24	0	0	to	24	10	0
Do., V.M. ex-whse.	24	0	0	to	24	10	0
Rods					26	0	0

ANTIMONY

English	64	10	0	to	65	10	0
Chinese, ex-whse.					54	0	0
Crude, c.i.f.					25	0	0

QUICKSILVER

Quicksilver	12	18	6	to	12	19	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—							
25%					8	17	6
45/50%	11	10	0	to	12	15	0
75%	16	12	6	to	17	17	6
Ferro-vanadium—							
35/50%					12/8 lb. Va.		
Ferro-molybdenum—							
70/75% carbon-free					4/6 lb. Mo.		
Ferro-titanium—							
20/25% carbon-free					9d. lb.		
Ferro-phosphorus, 20/25%					£21 to £22		
Ferro-tungsten—							
80/85%					3/1½ lb.		
Tungsten metal powder—							
98/99%					3/3 lb.		
Ferro-chrome—							
2/4% car.					21	10	0
4/6% car.					21	0	0
6/8% car.					21	0	0
8/10% car.					21	0	0
Ferro-chrome—							
Max. 2% car.					33	10	0
Max. 1% car.					36	5	0
Max. 0.50% car.					37	5	0
70% carbon-free					9½d. lb.		
Nickel—99.5/100%					£200 to £205		
"F" nickel shot					£184	0	0
Ferro-cobalt, 98/99%					6/3 to 6/9 lb.		
Metallic chromium—							
96/98%					2/5 lb.		
Ferro-manganese—							
76/80% loose	£11	5	0	to	11	15	0
76/80% packed	£12	5	0	to	12	15	0
76/80% export					£10	5	0
Metallic manganese—							
94/96% carbon-free					1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel	3	3	0	to	3	4	0
Mixed iron and steel	2	18	0	to	3	0	0
Heavy cast iron	2	18	0	to	3	0	0
Good machinery	3	2	0	to	3	4	0
Cleveland—							
Heavy steel	2	17	6	to	3	0	0
Steel turnings	2	0	0	to	2	5	0
Heavy cast iron					3	5	0
Heavy machinery					3	7	6
Midlands—							
Light cast-iron scrap	2	12	6	to	2	15	0
Heavy wrought iron					3	5	0
Steel turnings					2	0	0
Scotland—							
Heavy steel					2	17	6
Ordinary cast iron					3	4	0
Engineers' turnings					2	2	6
Cast-iron borings					1	17	9
Wrot-iron piling	3	9	0	to	3	10	0
Heavy machinery	3	8	6	to	3	9	6

London—Merchants' buying prices, delivered yard.

Copper (clean)	32	0	0
Brass	20	0	0
Lead (less usual draft)	16	15	0
Tea lead	12	10	0
Zinc	8	15	0
New aluminium cuttings	74	0	0
Braziery copper	29	0	0
Gunmetal	30	0	0
Hollow pewter	142	0	0
Shaped black pewter	107	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/-
,, No. 4	74/-
Forge No. 4	74/-
Hematite No. 1	85/6*
Hematite M/Nos.	85/-*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/-*
Malleable iron d/d Birm.	125/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/-
,, No. 3 fdry.	80/-
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/-
,, fdry. No. 3	80/-
,, fdry. No. 1	83/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Cleveland No. 3, Glasgow	78/-
,, ,, Falkirk	75/-
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/-*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/-
Staffs fdry. No. 3	83/-
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	91/6
Clyde, No. 3	91/6
Monkland, No. 3	91/6
Summerlee, No. 3	91/6
Eglinton, No. 3	91/6
Gartsherrie, No. 3	91/6
Shotts, No. 3	91/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)					10	10	0
Nut and bolt iron	8	17	6	to	9	7	6
Hoops			11	7	6 and up.		
Marked bars (Staffs) f.o.t.					13	0	0
Gas strip			11	7	6 and up.		
Bolts and nuts, ¾ in. × 4 in.					16	0	0 and up.
Steel—							
Plates, ship, etc.	9	7	6	to	9	10	0
Boiler plts.	9	17	6	to	10	0	0
Chequer plts.					11	0	0
Angles					9	0	0
Tees					10	0	0
Joists					9	7	6
Rounds and squares, 3 in. to 5½ in.					10	0	0
Rounds under 3 in. to ⅜ in. (Untested)					9	7	0
Flats—8 in. wide and over					9	5	0
,, under 8 in. and over 5 in.					9	10	0
Rails, heavy	8	5	0	to	8	10	0
Fishplates					12	10	0
Hoops (Staffs)					10	2	0
Black sheets, 24g. (4-t. lots)					12	0	0
Galv. cor. shts. (,,)					14	0	0
Galv. flat shts. (,,)					14	10	0
Galv. fencing wire, 8g. plain					15	0	0
Billets, soft					6	2	6
Billets, hard	7	2	6	to	7	7	6
Sheet bars					6	0	0
Tin bars					6	0	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	12½d.
Tubes	14d.
Castings	12½d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.58
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	30.00
Sheet bars	30.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.50
Sheets, galv., No. 24	3.20
Wire nails	2.10
Plain wire	2.40
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 31/-
,, furnace	24/- to 25/-
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/9
,,	28×20 ,,	37/6
,,	20×10 ,,	27/-
,,	18¾×14 ,,	19/6
C.W.	20×14 ,,	15/6 to 15/9
,,	28×20 ,,	33/9 to 34/-
,,	20×10 ,,	22/6 to 22/9
,,	18¾×14 ,,	15/3 to 16/-

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6	0	0	to	£7	0	0
Bars-hammered, basis	£16	0	0	to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	0	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£25	0	0	to	£28	0	0
Faggot steel	£18	0	0	to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0	to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.	
Sept. 17 ..	38	16	3	dec. 2/6
„ 18 ..	38	18	9	inc. 2/6
„ 21 ..	39	2	6	„ 3/9
„ 22 ..	38	18	9	dec. 3/9
„ 23 ..	38	15	0	„ 3/9

Electrolytic Copper

	£	s.	d.	
Sept. 17 ..	43	5	0	No change
„ 18 ..	43	5	0	„ „
„ 21 ..	43	10	0	inc. 5/-
„ 22 ..	43	10	0	No change
„ 23 ..	43	2	6	dec. 7/6

Standard Tin (cash)

	£	s.	d.	
Sept. 17 ..	194	10	0	inc. 5/-
„ 18 ..	198	5	0	„ 75/-
„ 21 ..	198	0	0	dec. 5/-
„ 22 ..	195	5	0	„ 55/-
„ 23 ..	192	5	0	„ 60/-

Tin (English ingots)

	£	s.	d.	
Sept. 17 ..	195	0	0	inc. 10/-
„ 18 ..	198	5	0	„ 65/-
„ 21 ..	198	5	0	No change
„ 22 ..	195	5	0	dec. 60/-
„ 23 ..	192	10	0	„ 55/-

Spelter (ordinary)

	£	s.	d.	
Sept. 17 ..	14	6	3	dec. 2/6
„ 18 ..	14	1	3	„ 5/-
„ 21 ..	14	1	3	No change
„ 22 ..	14	1	3	„ „
„ 23 ..	13	17	6	dec. 3/9

Spelter (Electro, 99.9 per cent.)

	£	s.	d.	
Sept. 17 ..	16	6	3	dec. 2/6
„ 18 ..	16	1	3	„ 5/-
„ 21 ..	16	1	3	No change
„ 22 ..	16	1	3	„ „
„ 23 ..	15	17	6	dec. 3/9

Lead (soft foreign, prompt)

	£	s.	d.	
Sept. 17 ..	18	8	9	dec. 2/6
„ 18 ..	18	7	6	„ 1/3
„ 21 ..	18	7	6	No change
„ 22 ..	18	3	9	dec. 3/9
„ 23 ..	18	0	0	„ 3/9

Lead (English)

	£	s.	d.	
Sept. 17 ..	20	10	0	No change
„ 18 ..	20	10	0	„ „
„ 21 ..	20	10	0	„ „
„ 22 ..	20	5	0	dec. 5/-
„ 23 ..	20	0	0	„ 5/-

A COMPARISON OF SCRAP PRICES

Average Monthly Prices of Cast-Iron Scrap in the Principal Districts in the Years 1930–36

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
SCOTLAND (Heavy Machinery)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1930..	3 10 0	3 9 6	3 8 6	3 8 3	3 8 1	3 5 9	3 3 2	3 3 4	3 3 0	3 0 9	2 19 4	2 17 8	3 4 9
1931..	2 15 0	2 15 0	2 13 3	2 10 8	2 9 9	2 8 3	2 8 6	2 7 9	2 5 6	2 9 8	2 14 5	2 15 9	2 11 2
1932..	2 15 0	2 15 0	2 12 6	2 10 6	2 7 6	2 5 3	2 4 5	2 3 10	2 4 10	2 4 4	2 4 0	2 4 8	2 7 8
1933..	2 7 0	2 9 3	2 10 8	2 10 5	2 9 5	2 9 3	2 8 6	2 10 9	2 10 4	2 10 7	2 10 10	2 12 4	2 9 11
1934..	2 14 2	2 17 9	2 18 5	2 18 3	2 15 5	2 15 9	2 14 3	2 15 0	2 15 9	2 15 0	2 15 8	2 16 3	2 16 0
1935..	2 15 5	2 15 8	2 15 10	2 16 4	2 16 10	2 17 0	2 16 9	2 16 9	2 17 0	2 16 11	2 19 11	3 2 7	2 17 5
1936..	3 4 8	3 9 10	3 10 11	3 11 10	3 10 8	3 9 10	3 9 2	3 8 9	—	—	—	—	—

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
N.E. COAST (Heavy Qualities)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1930..	3 4 6	3 4 1	3 3 3	3 2 6	3 0 5	2 19 5	2 17 9	2 16 3	2 16 3	2 13 4	2 6 6	2 11 9	2 18 6
1931..	2 10 4	3 9 8	2 9 7	2 8 3	2 6 3	2 3 8	2 2 9	2 1 9	2 1 0	2 2 1	2 9 9	2 6 8	2 5 11
1932..	2 6 3	2 5 8	2 3 0	2 0 8	1 19 0	2 1 0	1 15 9	1 15 6	1 15 6	1 15 6	1 17 4	1 19 10	1 19 7
1933..	2 1 1	2 2 2	2 4 9	2 3 5	1 18 9	1 19 6	2 0 0	2 0 0	2 1 3	2 5 8	2 7 10	2 10 1	2 5 4
1934..	2 12 7	2 15 1	2 13 7	2 11 6	2 11 11	2 13 9	2 11 0	2 10 6	2 11 3	2 11 10	2 13 9	2 13 3	2 12 4
1935..	2 12 2	2 13 0	2 12 7	2 13 0	2 12 9	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 16 10	2 12 10
1936..	3 0 0	3 1 10	3 1 8	3 2 2	3 4 6	3 3 9	3 5 9	3 4 1	—	—	—	—	—

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
S. WALES (Heavy Cast Iron)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1930..	3 18 5	3 18 9	2 19 0	2 18 8	2 17 2	2 16 2	2 14 8	2 13 10	2 14 1	2 12 7	2 8 5	2 5 11	2 14 0
1931..	2 7 7	2 8 3	2 9 9	2 8 1	2 6 11	2 5 2	2 2 9	2 2 2	2 0 11	2 3 9	2 7 6	2 7 10	2 5 9
1932..	2 7 2	2 6 8	2 6 4	2 5 0	2 4 8	2 0 8	1 19 4	2 1 7	2 1 10	1 18 10	1 19 8	2 2 1	2 2 0
1933..	2 3 4	2 4 6	2 4 6	2 4 1	2 3 5	2 2 8	2 3 7	2 4 8	2 5 8	2 5 9	2 5 7	2 5 0	2 4 5
1934..	2 6 10	2 8 9	2 7 8	2 6 6	2 7 6	2 8 0	2 6 10	2 6 7	2 8 0	2 8 2	2 9 1	2 11 5	2 7 1
1935..	2 11 3	2 11 4	2 11 1	2 11 3	2 12 0	2 11 1	2 11 1	2 11 0	2 12 2	2 13 10	2 14 5	2 14 8	2 11 9
1936..	2 16 3	2 18 7	2 18 9	2 19 2	2 18 7	2 18 7	2 19 0	2 19 0	—	—	—	—	—

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All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

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COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOUNDRY Manager with first-class experience and qualifications, at present in charge of large repetition grey-iron foundry, seeks change. Capable of taking entire charge, and can guarantee results.—Write Box 902, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

STEELFOUNDRY Metallurgist, with 15 years' experience complete control electric steel production, desires change. Willing to accept moderate commencing salary in suitable position. Thorough practical knowledge carbon and alloy steels, heat-treatment, foundry practice, costing. Competent to take sole charge steelfoundry.—Box 912, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Position as Foreman or Assistant. Comprehensive practical experience, engineering; machine-moulding; modern methods. Technical knowledge. Keen and energetic.—Box 910, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Position as Foreman or Assistant. Experienced jobbing; repetition; high-duty and ordinary cast iron. Age 30. Guaranteed to get results.—Box 896, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FIRST-CLASS Foundryman for Australian Agricultural Works to technically report upon present methods in production of grey-iron, malleable and steel castings; also to make recommendations for mechanisation of foundry. Two years' engagement; first class passage paid. Write full particulars: H. S. PEARCE & Co., LTD., Aldwych House, London, W.C.2.

GENERAL Foundry Hand, iron and non-ferrous jobbing; thoroughly acquainted all branches; new South Coast foundry near London. Experience, wages, Box 906, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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IRON FOUNDRY.—Well equipped and recently modernised, situated in the heart of an industrial area in the West Riding of Yorkshire, with a capacity of 30/40 tons per week. An appreciable volume of business is assured, and the proposition is an attractive one to the right people. Inspection invited.—Box 830, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C 2.

PROPERTY

MODERN Steelfoundry at Rotherham, main building 65 ft. by 150 ft. (erected 1916); complete with 10-ton crane. Site 1 acre. Siding on L.N.E. Rly. Adjacent canal.—Apply: GORDON, P.O. Box 98, Sheffield.

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WANTED.—10/15-ton Electric Gantry Crane, 47 ft. 4 in. span, 400 volts, 3-phase, 50 cycles. Full details and price to: Box 904, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & Co., LTD., Station Works, Ecclesfield, Sheffield.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

Tilghman Sandblast Barrel Plants; barrel sizes—60 in. x 40 in.; 36 in. x 20 in.; 20 in. x 30 in.

Tilghman Sandblast Cabinet Plants; 4 ft. 6 in. and 3 ft. 6 in. square (one for high pressure 70 lbs. per sq. in.); also small Cabinet 30 in. dia.

All complete with Air Compressors, etc.

Gas and Air Mixer by Sharpe & Preston, 2-in. outlet.

Six Osborne Pneumatic Jolt Press Moulding Machines, size 75J.

Three Mumford Yoke Headpress Pneumatic Moulding Machines.

Two Herbert Whizzer Sand Disintegrators.

Two Brealey Type ditto.

Heavy Double-ended Grinding Machines by Rowlands, Luke & Spencer, etc.

Hand Moulding Machines by Adaptable Darling & Sellars, Pridmore, Samuelson, etc.

500 Electric Motors, Dynamos, Rotary Converters, etc.

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Inclining TUMBLING BARREL (Canning); 22" dia. barrel x 18" deep; 50 r.p.m. 12" dia. F. & L. pulleys.

STEAM TURBO-BLOWER (Thomson-Houston); cap. 15,300 cub. ft. per min.; direct-driven by steam turbine.

Three first-class second-hand Green's standard FUEL ECONOMISERS, each of 320 pipes; 9' long; re-insurable at 200 lbs. per sq. in.

Write for "Albion" Catalogue.

Grams: "Forward." 'Phone: 23001 (10 lines).

ALBION WORKS, SHEFFIELD.

MISCELLANEOUS

BUY SKELMERSDALE STRAW ROPES, double-stranded, specially spun for core-making, prompt delivery, direct from the makers.

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GENUINE Southport Wind Blown Sand, which makes best oil-sand cores. Prompt deliveries by road into works.

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SAND MERCHANT,
SOUTHPORT.

PATTERNS IN WOOD AND METAL for all branches of Engineering. Moulding methods carefully considered.—FURMSTON & LAWLOR, Letchworth.

MISCELLANEOUS—*Continued*

WHY WASTE MONEY by paying too high a price for your Blacking? Blacking of the highest quality, but quoted at very low prices, is obtainable from JACK HIBBERT & COMPANY, LIMITED, T.G. Dept., Octagon Works, Vicarage Road, Battersea, S.W.11. Send for free 1-cwt. sample for testing.

'Phone: 287 SLOUGH

MOULDING MACHINES

Two Tabor Modern Jolt Squeeze and Pattern Draw Machines for boxes 20" × 14"; as new. Price £65 each.

One ditto, for 20" square Boxes. Price £70.

Several reconditioned GRIMES Hand Pattern-draw and Turnover Machines. Price £12 each.

One genuine OSBORN Hand Machine. Price £28.

Several nearly new DENBIGH Jolters. CHEAP!

CUPOLETTE, 30" dia., NEW. Price £26.

PLEASE SEND US YOUR ENQUIRIES.

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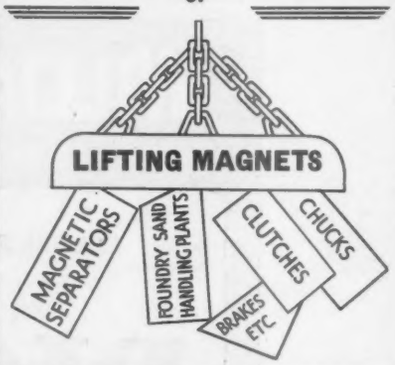

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